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Department of Industries
Sea Fisheries Branch

FISHERIES BULLETIN

7

CONTRIBUTIONS TO OCEANOGRAPHY AND FISHERIES BIOLOGY

Cape Town

1976

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SEAWEEDS OF SOUTHERN AFRICA: GUIDE-LINES FOR THEIR STUDY AND IDENTIFICATION

R. H. SIMONS
(Illustrated by M.L. Branch and the author)

Seaweeds include in their ranks the largest known organisms but at the same time some which are virtually microscopic. Their great value both in their natural environment and in the affairs of man makes some acquaintance with them desirable. Yet this exercise is no easy task because of the need to use microscopic and other obscure characteristics to identify them. Any attempt therefore to name all seaweed species on the basis of external appearance alone is bound to fail.

Nevertheless, if any understanding of these interesting and often beautiful plants is to be achieved by the uninitiated, an effort must be made to identify those species in a local flora that are morphologically discrete. And this is what the present key tries to do; as far as possible, shapes and superficial features discernible, when magnified up to ten times, are used as determining characteristics.

On the other hand, seaweed taxonomy should not be left entirely cloaked in mystery and a statement of the criteria on which it is based follows the key. This part of the work is directed at those who through interest or necessity require initiation into this subject. The aim here is to introduce the reader to morphological features peculiar to seaweeds and to show how these are important in establishing possible phylogenetic connections or natural interrelationships. A glossary of terminology is also included as an aid to an understanding of this subject.

Since the superficial features of the seaweeds are of so little importance in identification and phylogeny, the proximity of species in the key is no indication of natural connection. Information on these connections appears in the classification scheme which follows the sections dealing with structure and reproduction. The index which terminates the book links the taxa mentioned in the key with those that are listed in the classification scheme.

Certain references are cited in the text and these will be found in the literature list which includes a few other titles the reader might usefully consult.

Immediately following this introduction are discussions of seaweed value and distribution. Sections on seaweed collection, preservation and recognition precede the identification key. These preliminary sections aim to provide the user with some background knowledge which facilitates use of the key.

Queries or comments about seaweeds may be addressed to the *Director of Sea Fisheries, Private Bag, Sea Point, 8060.*

VALUE

Industrial uses

Among useful seaweeds is the South African kelp *Ecklonia maxima* (Fig. 54). This plant, like many other members of the Brown seaweeds (a Division of Algae), yields alginic acid which has outstanding properties as an emulsifier, an emulsion-stabilizer and as a smoothing agent. There is a wide literature, some listed among the references included in this book, on the subject of alginic acid and its industrial use – so there is no need to go into details here. It is, however, a matter of interest to mention the contribution that South Africa makes towards the alginate industry.

Agar, another unique seaweed product, is outstanding for its special gelling and other properties which make it particularly suitable for use in bacterial culture work. Like alginic acid, agar and its uses are widely documented and only South African aspects of the subject will be mentioned here.

The alginate industry dates from about 1910, and agar extraction, so far as Western countries are concerned, started during the Second World War.

Alginic acid – The main source of alginate as far as South Africa is concerned is *Ecklonia maxima* (Fig. 54). Of lesser importance is *Laminaria pallida* (Fig. 53) which forms a differential proportion of the large beach-casts of kelp to be

seen along so much of South Africa's western coastline and her southern shore as far east as Cape Agulhas. As can be seen from the Figures, these two species have elongated trunk-like portions topped by leafy parts. Because of the especially glutinous nature of the leafy parts, sand easily clogs this portion of the plant. Since sand is an undesirable contaminant, the leafy portions are often lopped off and only the trunks collected. Whatever is collected is dragged up the beach beyond the reach of incoming tides and there left to dry before removal by motor vehicle to the site of a mill. At the mills the raw kelp is hammered into thumb-nail sized pieces and bagged in sugar-pockets. In this state, the kelp is exported to foreign countries where it receives further processing.

Japan, at this time, takes most of our kelp harvest which annually amounts to about 5 000 metric tons (dry mass). South Africa's kelp earns a yearly income of about R750 000 instead of the potential of several millions of Rands which would be realized were it to be fully processed within our borders.

Agar – Before 1974, between 1 500 and 2 000 metric tons (dry mass) of *Gracilaria verrucosa* (Fig. 159) were beached every year on the northern shore of Saldanha Bay on the West Coast. From about 1942 it was realised that this plant is a rich source of agar and a local manufacturing industry was begun. This was during the Second World War when supplies of agar were almost impossible to obtain from Japan which previously had supplied nearly the entire world-needs of this valuable seaweed extract. The South African product could not, however, compete with that of the Japanese and after the War such was the demand for raw material for agar manufacture by Japan that most of the *Gracilaria* collected at Saldanha Bay was exported as raw material. The original but smaller local extracting industry persisted until about the mid-fifties by which time almost all *Gracilaria* was exported.

Several years elapsed before agar-extraction was re-started in South Africa and in the latter half of the 1960's two factories were operating. In spite of this, export of raw material to Japan continued, largely because the local processing industry could not command all the *Gracilaria* available.

During 1974, the cast of *Gracilaria* at Saldanha Bay dropped dramatically to about one-tenth of previous averages; 1975 has shown no improvement and the local extraction of agar has once again ceased. This change seems to be connected with the development of the Bay for iron-ore carriers. Up to 15 per cent of the dry mass of *Gracilaria* is agar, selling at up to R20 000 per ton, so that a potential income of more than a million Rands is involved.

Casts of *G. verrucosa* in Saldanha Bay occurred only in specific wind and surf conditions, which meant that exploiters had, day and night, to watch for these circumstances so as to lose as little of the crop as possible when it became available. Losses could be heavy because of the quantities of silt deposited together with the plant. Once covered with silt the seaweed was either impossible or not easy to collect. After its removal from the beach, the *Gracilaria* was thinly spread on open fields where, with daily turning, it was left to dry and bleach. When dry the bulk of the harvest was removed to barns, then baled and transported to Cape Town depots to await shipment to Japan; local processors obtained their own supplies of raw material in competition with other collectors.

There are, in South Africa, other seaweeds supplying agar, but they occur in relatively small quantities and they must be harvested from the rocks on which they grow. These are the species of *Gelidium* (Figs. 90, 150 and 151).

Other polysaccharides – South African species like *Gigartina radula* (Fig. 126), *G. stiriâta* (Figs. 48, 113 and 128) and *Aeodes orbitosa* (Fig. 109) yield agaroids which do not gel in watery solution unless chemically treated. Agaroids are often called carrageen(an)s and these are widely used as alternatives for agar.

Hypnea spicifera (Figs. 45 and 158) is a good source of so-called gelan which forms an excellent and strong gel in aqueous solution.

None of the above-mentioned plants is much collected here for agaroid recovery.

Seaweeds as food

Very little seaweed is consumed by Western peoples, although certain species are much in demand by Japanese and other Orientals. Of those that are eaten, *Porphyra* species constitute the greatest bulk and Nori-culture (*Porphyra*-farming) represents the most important and profitable of marine undertakings; this modern industry is valued at about R150 million annually. *Porphyra* has a high protein-content and contains many vitamins. Other seaweeds, too, are known to have a variety of essential amino-acids (Simons 1971) and a number of vitamins (Kanazawa 1963); some, indeed are renowned or are becoming recognized for desirable pharmaceuti-

cal properties (Springer *et al.* 1957, Bernardi and Springer 1962, Miura 1975 and Takagi 1975). There seems every reason, therefore, that seaweeds could profitably be introduced into our everyday diets.

Few studies have been made into the effects on subjects using seaweeds as food, but one especially notable one took place, under experimental conditions, in Norway (Jensen *et al.* 1968). The subjects in this case were seven pairs of homozygous twin-cows. Each pair was divided into an experimental and a control animal – the experimental animal had a diet supplemented by a fortified seaweed meal while the control had a diet including a standard inorganic mineral-supplement. The minerals supplied in the two cases were essentially equivalent as were also the costs involved. The cows fed on seaweed produced significantly more total milk over the full seven-year period through which the experiment lasted.

Seaweeds in agriculture

Farmers of coastal lands on the European continent have traditionally used seaweed as agricultural fertilizer and their rights to this material are sometimes protected by law, as for instance on the English Channel island of Jersey. In South Africa similar practices have not developed, but many a gardener in the environs of Cape Town enthusiastically uses 'seabamboos' (*Ecklonia maxima*, Fig. 54) as a fertilizer for growing vegetables and flowers. Such seaweed usage undoubtedly improves soil-texture in a way which few other fertilizers match.

Natural role

Seaweeds tend to occupy ecological niches where there is a high nutrient-turnover and maximum aeration. Because of this and the fact that their entire surfaces are involved in photosynthesis, it is hardly surprising that calculations of their productivity of organic material indicate that seaweeds are scarcely equalled by other plants (Mann 1970). This means that there is an enormous output of food by seaweed beds. Much of this food occurs either as particulate or dissolved matter. Among grazers of whole seaweeds are molluscs such as perlemoen, periwinkles, alikreukel and limpets; fish such as hottentots; and many sea-lice. Grazing of seaweeds does not only take place within the sea but also on beaches where much of it is cast in the ordinary course of events; here sand-hoppers and sea-lice feast on it. But probably the greatest beneficiaries are the particle-consumers like black and ribbed mussels.

Within the sea, seaweeds have physical roles as well as being providers of food. For instance, large kelps influence wave-action in much the same way that trees on land affect wind. In this capacity the presence of these plants enables the survival of many species of animals which would otherwise be intolerably buffeted. Kelp, as also smaller seaweeds, provide footholds and special ecological niches for many different kinds of tiny creatures. North (1971) lists upwards of 900 animal species in kelp-forests off California and this clearly illustrates the ecological importance of seaweed groves.

Harvesting rights in South Africa

With the realization of the immense natural importance that seaweeds have, it is scarcely surprising that the authorities in South Africa regard uncontrolled exploitation of seaweeds warily. For this reason, the Department of Industries, through its Sea Fisheries Branch, now maintains a strict control of commercial activities involving seaweed harvesting. Neither kelp nor *Gracilaria verrucosa* may be taken directly out of the sea but may be collected only after being cast ashore in the natural course of events. The other seaweed species may be harvested where they are attached, but considering the small supplies available little activity centres on these.

Rights to collect seaweeds are granted to successful tenderers. For the purpose of tender, the South African shore (effectively, only the Cape Province is involved) is divided into 15 stretches. Only one concession-holder is permitted in each of these stretches. Collections are monitored and records of these are sent to the Sea Fisheries Branch every month.

The above very briefly outlines the present importance to South Africa of its seaweed resources. Given the sort of attention accorded to land plants, seaweeds could become more productive and industrially more rewarding.

DISTRIBUTION

It was mentioned that *Gracilaria verrucosa* (Fig. 159) occurs, in large quantities, only in

Saldanha Bay, about 80 km north of Cape Town. It was stated, too, that *Ecklonia maxima* (Fig. 54) occurs in beach casts along the west and south-western coasts of the Cape Province. These statements point to the fact that specific seaweeds have particular distributions.

The distributions of the species identified in the key are indicated by bracketed entries which refer to an outline map on p. 62. It will be noticed that there is a tendency for most species listed to occur either west or east of Cape Agulhas. This seems remarkable since there is no obvious barrier at Cape Agulhas that would dictate such a division. This distribution might at first sight appear to be decided by geographic longitude, but the true explanation is much more complicated and hinges on the different regimes of water-temperature.

Temperature

There exist many text-books on phycology which discuss factors generally influencing the distribution of seaweeds and all authorities find that water-temperature plays a major role. Nowhere better can this association of seaweeds with isotherms be more plainly seen than in South Africa. Here there exist well-defined cold- and warm-water regions, one on the West Coast and the other on the East Coast. What is more, these temperature régimes do not change much throughout the year although between them there is an area of mixing. The reasons for this set of circumstances are interesting: cold bottom water of South Central Atlantic origin wells up, especially during summer, along the West Coast under the influence of strong southerly winds; the East Coast, however, is washed by the Agulhas Current arising in the tropical Indian Ocean and moving in a south-westerly direction. This Agulhas Current cools progressively during its south-western migration because of its contact with colder water drifting in from the south and south-west.

Thus emerges a set of conditions in which the temperatures on almost the entire West Coast south of the Cunene River, which separates Angola and South West Africa, vary between 8°C and 16°C, while temperatures in Durban seldom drop much below 20°C and tend to remain in the middle twenties throughout the year. The gross effects of the Agulhas Current cease at Cape Agulhas, the southern-most tip of Africa. Between Cape Agulhas and the Cape of Good Hope (Cape Point) there is an area of water-mixing made up of west-drifting tongues of Agulhas Current water, cold upwelled water and southern surface water. The temperatures experienced inshore in this south-western area are very variable but tend always to be cooler than in the regions under the direct influence of the Agulhas Current.

False Bay, in the extreme west of this south-western area is an anomaly in that its northern waters can have summer temperatures rising as high as those typical of Port Elizabeth. This U-shaped bay, about 30 km long and the same wide, opens to the south with Cape Point forming the western tip and Cape Hangklip its eastern tip. During summer, onshore southerly winds prevail, causing a damming effect and allowing the sun to warm the water. The same wind tending to move from an easterly quarter helps to drive Agulhas water into the Bay. These summer conditions are reversed in winter when northerly winds prevail, thus driving water out of the Bay and causing upwelling of cold bottom water; winter temperatures in the north of the Bay drop to those of the West Coast (12 – 14°C). Strong inflows of cold freshwater during winter run-off hasten this cooling process. The effect on seaweed distribution is a predominance of eurythermal and warmer-water species along the northern coast of False Bay, which contrasts greatly with the seaweeds growing in the south of and outside the Bay. Thus, for instance, emerald-green *Hypnea spicifera* (Figs. 45 and 158), *Gigartina pistillata* (Fig. 168) and *Caulerpa filiformis* (Fig. 10) are common species in the northern reaches, whereas *Ecklonia maxima* (Fig. 54), *Gigartina stiriata* (Figs. 48, 113, and 128) and *Epymenia obtusa* (Fig. 116) tend to dominate the southern extremities. The fact that typical East Coast species do not occur in the north of False Bay, even though summer temperatures would favour their growth, is probably the result of winter conditions reducing water-temperature to levels precluding survival of such plants.

Although it is unlikely that this deduction has escaped notice, it is as well to draw attention to the part played by wind-direction and strength in affecting the temperature-regimes of both the South and West Coasts.

Littoral and sublittoral zones

Temperature-tolerance does not alone explain distribution-patterns of specific species, nor are the factors entirely physical. One finds, for instance, that *Hypnea spicifera* (Figs. 45 and 158)

occurs along the entire coast, thus indicating a high degree of tolerance to change in water-temperature (eurythermal species); yet, in its western distribution it is strictly sublittoral and solitary, whereas in its eastern habitat it flourishes best in the lowest area of the intertidal belt where it is highly gregarious. This reference to the lowest area of the intertidal belt raises the matter of tidal movements. It should be realized that ebb- and flood-tides reach different heights during spring- and neap-tides. During low spring-tides, coinciding with full- and new-moon periods and occurring approximately every fortnight, a larger portion of the shore is uncovered than at other times; it is the extra portion uncovered only at spring-tides that forms the lowest area of the intertidal. In South Africa, this extra portion has been called the Cochlear Zone (Stephenson 1939). Why *Hypnea spicifera* should be better able to withstand a certain degree of atmospheric exposure in elevated water temperatures is not at all understood. There is a further comment to make about *Hypnea spicifera* in its two temperature-habitats: in warm water, it is nearly always emerald-green, whereas in cold water it is dull purple.

Vertical zonation

Most of the intertidal region, which in South Africa has a maximum vertical height of two metres, is colonized by a large variety of sedentary animals and benthic Algae that never occur in the sublittoral zone. The vertical movement of the sea at full neaps is slightly more than one metre; splash and spray can effectively extend the upper limit of the ranges. It will quickly be realized that intertidal seaweeds are almost always associated with hard substrata and rarely with sandy beaches. Next it may be seen that the various intertidal species are confined more or less to particular contours or horizontal belts (vertical zonation). The vertical zonation visible on the South African shore has been described by Stephenson (1936 - '48) and others in a series of papers. Stephenson *et al.* (1937) concluded that there are four clearly recognizable zones in the intertidal belt, which they termed Littorina Zone, Balanoid Zone, Cochlear Zone and Sublittoral Fringe Zone. Of these only the Littorina and Balanoid Zones are exposed at every low tide, while the Cochlear Zone is uncovered during all spring-tides. Only rarely, at extreme low tides, is the Sublittoral Fringe Zone exposed to the atmosphere. These Zones are characterized by concentrations of particular kinds of animals which are easy to recognize.

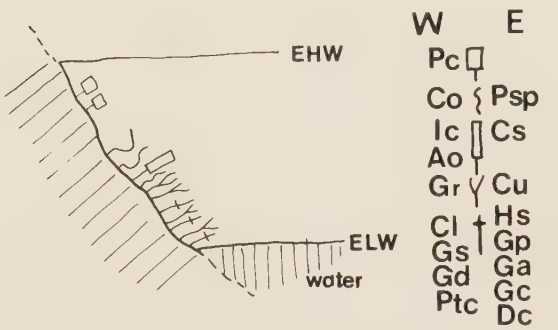
What is not appreciated when working on the shore is that vertical zonation extends into the sublittoral as well.

Intertidal zonation -. On the west coast of the Cape Peninsula, the only significantly large seaweed present in the Littorina Zone is *Porphyra capensis* (Fig. 108). There the Upper Balanoid Zone is usually bare of plants while the Lower Balanoid Zone becomes progressively more populated downwards, starting with patches of *Chaetangium ovale* (Fig. 47), *Caulacanthus ustulatus* (Fig. 156), *Splachnidium rugosum* (Fig. 52) and *Aeodes orbitosa* (Fig. 109); then giving much more continuous cover, *Gigartina radula* (Fig. 126), *Iridaea capensis* (Fig. 129) mixed with *Splachnidium rugosum* and *Aeodes orbitosa.* Below these, the Cochlear Zone is dominated by lithothamnia (Fig. 65) providing an almost uninterrupted coating of the surfaces; besides these are many erect forms such as *Champia lumbricalis* (Fig. 144), *Cladophora capensis* (Fig. 21) and *Gigartina stiriata* (Figs. 48, 113 and 128). The Sublittoral Fringe coincides with the uppermost limits of attachment for the kelps (Figs. 53, 54 and 56). Within the sublittoral itself is a mass of small species, many illustrated in this book, which form an often thick undergrowth to the tall kelps. Some of these smaller sublittoral species worthy of mention are *Epymenia obtusa* (Fig. 116), *Botryocarpa prolifera* (Fig. 123) *Rhodymenia* spp., *Cladophora mirabilis* (Fig. 19). *Codium stephensiae* (Fig. 41), *Pachymenia cornea* (Figs. 110 and 132), *Kallymenia schizophylla, Kallymenia agardhii, Gymnogongrus dilatatus* (Fig. 120) and, growing on kelp-stipes, *Carradoria virgata* (Fig. 183), *Suhria vittata* (Fig. 89) and *Carpoblepharis flaccida* (Figs. 103 and 152).

Something similar in the way of vertical zonation may be seen on the East Coast but the species involved are for the most part different. For instance, it is unusual to encounter *Porphyra capensis* (Fig. 108), but *Bostrychia binderi* and *B. tenella* – brown-coloured moss-like turfs often growing on shaded vertical surfaces – and *Endarache binghamiae* (Fig. 115) may be seen in the Littorina Zone. In the Upper Balanoid Zone there are usually no seaweeds (cf. West Coast) while the lower Balanoid Zone is characterized by turfs including species like *Caulacanthus ustulatus* (Fig. 156) and *Gelidium reptans*; in addition, *G. pristoides* (Fig. 90), *Desmia hornemannii* (Fig. 101), *Caulerpa filiformis* (Fig. 10), *Laurencia nata-*

lensis (Fig. 172), *Amphiroa bowerbankii* (Fig. 70) and *Dictyopteris longifolia* (Fig. 85) are common in this Zone.

The Cochlear Zone shows stands of *Gelidium amansii* (Fig. 151), *G. cartilagineum* (Fig. 150), *Plocamium corallorhiza* (Fig. 98) and *Cladophora rugulosa* (Fig. 23), while the Sublittoral Fringe is often dominated by *Hypnea spicifera* (Figs. 45 and 158), *Plocamium cornutum* (Fig. 147), *Plocamium corallorhiza* (Fig. 98) and *Amphiroa ephedraea* (Fig. 71).

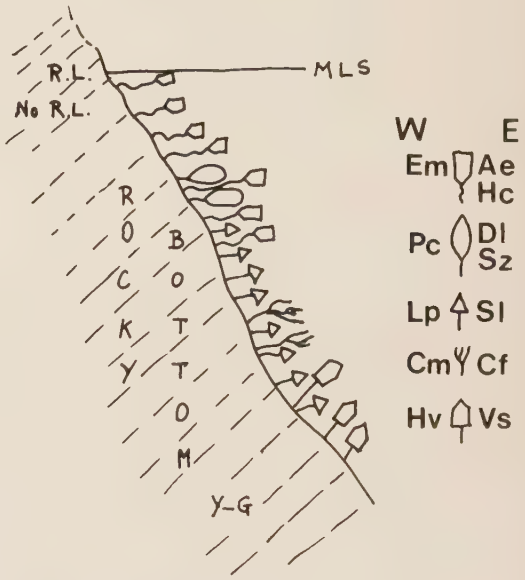


Some plants on typical intertidal slopes on the West and East Coasts

Ao: *Aeodes orbitosa*; Cl: *Champia lumbricalis*; C: *Chaetangium ovale*; Cs: *Caulerpa racemosa*; Cu: *Cladophora rugulosa*; Dc: *Dictyopteris macrocarpa*; E: East Coast; EHW: extreme high water; ELW: extreme low water; Ga: *Gelidium amansii*; Gc: *Gelidium cartilagineum*; Gd: *Gymnogongrus dilatatus*; Gp: *Gigartina paxillata*; Gr: *Gigartina radula*; Gs: *Gigartina stiriata*; Hs: *Hypnea spicifera*; Ic: *Iridaea capensis*; Pc: *Porphyra capensis*; Psp: *Padina* sp.; Ptc: *Pterosiphonia cloiophylla*; W: West Coast

Vertical zonation in the intertidal belt is apparently related to the differing tolerances that various species have for atmospheric exposure; those that can withstand prolonged drying, and in fact appear to require such conditions to survive, occur higher in the littoral zone whereas those that can tolerate no exposure grow in the sublittoral.

Sublittoral zonation - Seaweeds, being plants, photosynthesize and therefore require a source of light which must be adequate for their physiological needs. Water absorbs light rapidly, so that only the upper strata of the water-column are illuminated. Not only is the quantity of light attenuated in the water-column but quality, too, is affected. Thus the red end of the spectrum of visible light is filtered out within the first few centimetres of the surface; blue light has good penetration and yellow-green the best of all. On the South African coast, no photosynthetically significant light reaches levels much deeper than 30 metres where this depth represents the limit of seaweed colonization. At or near this limit, only a few species able to make use of minimum light-requirements occur. Most of these species are Red Algae and many are at present unidentified because they have been sterile with unknown affinities. A few that have been identified on the West Coast include *Hymenena venosa* (Fig. 93), *Botryocarpa prolifera* (Fig. 123), *Rhodymenia* sp., *Apoglossum* sp., *Kallymenia schizophylla, Ceramium planum*-complex (Fig. 155), *Plocamium suhrii* (Fig. 99) – all Rhodophyta – and *Axillariella constricta* (Fig. 139), a Brown Alga. Most of these identified species colonize almost every level of the photic zone below extreme low water, thus showing a remarkable adaptability to a wide range of light intensities and qualities.



Some plants on typical subtidal slopes on the West and East Coasts

Ae: *Amphiroa ephedraea*; Cf: *Caulerpa filiformis*; Cm: *Cladophora mirabilis*; Dl: *Dictyopteris longifolia*; E: East Coast; Em: *Ecklonia maxima*; Hc: *Halimeda cuneata*; Hv: *Hymenena venosa*; Lp: *Laminaria pallida*; MLS: mean low water of spring tide; Pc: *Pachymenia carnosa*; R.L.: light in the red wave-lengths; Sl: *Sargassum longifolium*; Sz: *Stypopodium zonale*; W: West Coast; Y–G: light in the yellow-green wave-lengths

The preponderance of Red Algae, not only here in South Africa but generally, at the lowest limits of the photic zone, and of Greens in the

upper reaches has encouraged ideas of the existence of chromatic adaptation whereby photosynthetic pigments are most likely to be complementary to the wave-length of available light. If such adaptation does operate, then Green Algae will occur where red light is available but will be absent where there is none. Brown and Red Algae, on the other hand, should be able to make use of light deficient in the longer wavelengths; Red Algae should best be able to use, through their complementary red pigment, wavelengths which reach the greatest depth.

Intertidal pools as special environments

Rather different circumstances from those outlined above operate within the many pools remaining at ebb-tide in depressions, gulleys and crevices of the rocky intertidal platform. Plants colonizing such pools, although often permanently submerged, may experience conditions very different from the shallows of the true sublittoral zone. Not only may there be no agitation of the water within such pools but temperatures, too, may rise or drop considerably. Rain may dilute pool-water thus significantly lowering salinity. Conversely, evaporation may significantly raise salinity.

Two species which exclusively inhabit shallow-water pools of the West Coast are *Grateloupia filicina* (Figs. 102 and 153) and *Chordariopsis capensis* (Fig. 163). Other species, such as *Gigartina scabiosa* (Fig. 166) and *Trematocarpus scutellatus* (Fig. 112.5), frequently occur in pools and in the shallow sublittoral as well. For northern Natal, non-exclusive pool-forms include *Galaxaura diessingiana* (Fig. 112), *Halimeda cuneata* (Fig. 6), *Sargassum elegans, S. heterophyllum*-group (Fig. 83), *Pseudocodium devriesei* (Fig. 28) and *Zonaria subarticulata* (Fig. 62). Species which seem to prefer pool-habitats in these warmer waters are *Valonia macrophysa* (Fig. 8) and *Padina commersonii* (Fig. 58).

Chemical factors

It will have been noticed that salinity – a chemical property of sea-water – was mentioned in connection with tolerance-characteristics of pool-Algae. There are other very important chemical factors operating in the marine environment and water-quality dictates to a marked degree what species may grow.

Thus, communities growing in nutrient-enriched (eutrophic) waters near sewage outfalls are altogether different from others in the vicinity. Eutrophic communities tend to have a much reduced species-composition and to be heavily infested with epiphytic diatoms (a group of microscopic Algae). Seaweeds with a surface-covering of diatoms have a drab monotony of colour not otherwise evident.

Levels of dissolved oxygen and phosphate and nitrate concentrations are other highly important chemical factors dictating successful colonizers of specific localities.

A matter concerned with water-quality currently receiving attention in many parts of the world, including South Africa, is the inflow into the sea of heavy metal ions from industrial wastes; changes that might occur in the biological communities as a result are being monitored as is also the selective absorption of such materials by economically important organisms.

Mechanical factors

Other factors affecting localized distribution could be classed as mechanical and include stresses such as wave-action, abrasion by suspended sand and other hard particles and competition for space.

Certain organisms in the sea are antagonistic to others, so that, when established in a virgin area, they are likely to exclude occupation by later comers. Such exclusion can be clearly seen where red-bait (*Pyura stolonifera*) forms continuous coverage of rocky surfaces in the Cochlear and Sublittoral Fringe Zones; no macrophytes appear able to grow in such an area although other conditions favour their growth. It is possible that red-bait tests offer an unsuitable surface for the attachment of seaweeds. Other substrata unsuitable for the attachment of most macroscopic seaweeds are sand and mud.

Wave-action can be severe, preventing stabilization of certain seaweeds; the same conditions on the other hand favour the luxurious growth of other seaweeds. Still other species will survive under varying degrees of wave-stress, either maintaining the same external appearance in all conditions or appearing morphologically differentiated as a result. Polymorphy resulting from differential exposure to wave-stress is found in *Cladophora capensis* (Fig. 21): where exposure is severe the filaments are short and little-branched; in calmer conditions within the littoral zone filaments have about the same length but are much branched; and in sublittoral

situations where wave-action is minimal filaments are elongated and much branched.

Mechanical abrasion by suspended matter, particularly sand, is tolerated by some species but not by others, so that specific floral communities, having the same constituent species, may become discontinuous as a result of differential particle bombardment. Since this factor is often closely allied to wave-action it is difficult to be specific about which is having the greater effect.

Species which seem immune to the effects of sand-movement (and indeed, have been seen to survive prolonged periods of burial in sand) are *Gigartina radula* (Fig. 126), *G. pistillata* (Fig. 168), *Phyllymenia belangeri* (Fig. 131) and *Caulerpa filiformis* (Fig. 10).

World distribution

I have attempted so far to indicate some of the environmental factors affecting seaweed-distribution on the South African coast. I have mentioned, too, that there are several hundred species and varieties to be found here. In terms of the world's population (numbers of kinds – not numbers of individuals) this is a significant proportion. Estimates of seaweed species around the globe are probably far from reliable, mainly because seaweed floras have received relatively little attention. Nevertheless, it seems that there are about 7 000 kinds of seaweed in the world, which means that South Africa possesses nearly one-tenth of these. This may seem remarkable until it is realized that seaweed floras along other national coasts are equally rich. What is remarkable, perhaps, is that something of the order of one-half of the South African species appear to be endemic to southern Africa. Caution is necessary when making claims of this sort because, through lack of good monographic records of small-sized species on a global scale there may in fact exist numerous examples of synonymity not yet discovered.

Certain Genera, as opposed to species, seem to show distinctive geographic limitation within, say, the Northern Hemisphere, while others seem to be strictly confined to only one landmass. Global regions are recognized as falling within categories such as Arctic, Antarctic, Subantartic and so on, but others are scarcely recognized. Chapman (1946) proposed a variety of floristic elements which he termed, for example, Boreal Atlantic, Boreal Pacific, Austral Atlantic and Austral Pacific for warm temperate water masses, Indo-Pacific for tropical waters of the Indian and Pacific Oceans between South-East Asia and Australia, and so on, but these have by no means received universal acceptance.

A few examples of existing generic distributions will point out the sort of difficulties that geographers are faced with. *Fucus* species (Fucales, Phaeophyta) occur only in the Northern Hemisphere, while *Schizoseris* species (Delesseriaceae, Ceramiales, Rhodophyta) and *Durvillea* species (Fucales, Phaeophyta) colonize only Southern shores. *Macrocystis pyrifera* (Lessoniaceae, Laminariales, Phaeophyta) is predominantly Subantarctic in distribution, yet the Pacific Coast of North America, north of the Tropics, has rich stands consisting of this and one other species. The same two species occur on cold temperate South American and Australasian shores. The southern portion of the South African west coast possesses what appear to be relict and patchy stands of *Macrocystis angustifolia* which is well represented on the South Australian shore. A Genus having almost exclusive Australasian confinement is *Cystophora,* but, as recently as 1970, the species *C. fibrosa* was newly described by the author as a constituent of the South African flora. *Ecklonia* species are not to be found in Europe, the Americas or the Subantartic but only in southern Africa, southern Australia and Japan. *Chordariopsis* is represented by a single species which occurs only on the west coast of southern Africa. *Gracilaria* species and *Colpomenia* species have global distribution.

The few examples quoted above serve to show that some Genera have wide, global distribution, whereas others are more or less geographically isolated. Explanations for distribution patterns lack conviction, because, for one thing, the fossil-record of marine Algae is almost non-existent, thus making it almost impossible to indicate algal distributions of the past. Very little, too, is known about speciation in Algae (Dixon 1963 and Powell 1963), with the result that generalized statements about marine algal geographical evolution are rather hypothetical. There do not appear, in present circumstances, to be a large number of species which are moved to new areas of colonization by artificial (accidental) or natural transporting mechanisms such as ships' bottoms, birds, winds and ocean currents; to what extent either whole plants or propagating units remain viable through prolonged flotation is not known. When one finds, for instance, as the writer has done, that *Plocamium beckeri* (Fig. 148) is common on the

South African east coast, is absent along the entire upwelling area of the West Coast and then reappears in the sublittoral of Angola, two explanations are possible. One is that *P. beckeri* was once continuous between the present western and eastern concentrations, but that owing to localized climatic changes, this continuum has been broken. A second explanation is that dissemination of *P. beckeri* occurs across a zone always antagonistic to its establishment as a constituent of the flora.

Of these alternatives, the first explanation seems more plausible, though why, after a period of geographical isolation amounting to several millennia, the isolated colonies should remain morphologically identical is not easily explained except on the basis of severely curtailed or non-existent evolutionary change.

Applications of distribution studies

An understanding of what determines natural distribution of species may appear to be rather academic, but its practical significance lies in resource management. If, for instance, it is intended to propagate a species by artificial culture, the organizers should take account of environmental preferences shown by the potential crop-plant. If on the other hand the aim is to harvest natural produce, the effects of removal of plants of the required species from the environment must as far as possible be predictable. Consideration of a different sort must be given to possible repercussions (economic, biological and social) of release into the sea of our wastes or of introducing exotic species. These repercussions should again be predictable and controllable if undesirable results are to be avoided.

The recounting of a recent event will help to illustrate these principles. Some research-workers successfully grew in French coastal waters, *Macrocystis pyrifera,* collected from the Subantarctic. Following the conclusion of the initial experiment, the area was cleared of all *Macrocystis.* A request to operate a second-phase development experiment was refused because France's maritime neighbours protested. The large groves of this giant plant, which forms tough ropy mats of floating fronds covering extensive areas, resulting from successful colonization, would create a serious hazard to shipping in such busy waterways as the English Channel. The reason for this exercise was to make available to France a ready raw-material source of alginic acid, which was mentioned above under Value. The implication here is that the experimenters could have caused an unexpected and uncontrollable situation.

COLLECTION AND PRESERVATION

It is necessary for accurate identification to collect seaweeds from their natural habitat and to preserve some for record purposes.

Good collections of littoral species may be made in the hour or so leading up to slack water of a spring tide. In southern Africa this usually involves the early hours of daylight between about 8 o'clock and 10 o'clock. Provided wave-action is sufficiently reduced, one can often reach species attached in the Sublittoral Fringe without too much difficulty. For sublittoral species skin-diving must be resorted to if one is to establish the siting of a species. Diving is best carried out at full tides and in SCUBA-gear. Notes about the location and habitat of a collected species should as far as possible be made immediately – it is possible to write in pencil on perspex slates under water. These notes should be applied to any relevant specimen which is stored.

Two methods of preservation are used – the wet and the dry. The wet method makes use of suitable preserving liquids in which the specimens are placed, whereas the dry method involves more or less standard botanical pressing techniques with slight modification.

The purpose of wet preservation is the maintenance of all the natural morphological features of the specimens. Two processes are involved: one, and this must occur in the shortest possible time, is the killing of every cell in the specimen, and the other is fixing of the material in the state in which it was killed. Both processes may be achieved by the same fluid but it by no means always happens. In some plants killing may be very slow and fixation almost impossible to achieve. In the latter event disintegration of the plant in the preservative may ensue. Choice of preservative thus is often a matter of skilled judgement. In general practice, a killing and fixing agent giving reasonably reliable results with most seaweeds is 5 – 10 per cent formalin in sea-water. Such a solution, however, is out of the question if cell nuclei are to be studied; in such cases a killing agent could include osmium tetroxide. The specimens should not be maintained in osmium tetroxide solutions but must be trans-

ferred to some other suitable preservative. Specimens to be examined under electron microscopes should be killed and preserved in gluteraldehyde/sea-water solution. There should be five to ten times more preserving fluid than plant material present. Whatever preservative is used the original colour of the seaweed seldom lasts long; for this purpose the dry method is more satisfactory.

The dry method of preservation is far more straightforward than the wet method and is not open to the hazard of disintegration of specimens as may occur in carefully treated wet specimens. The only real hazard in making dry mounts is that of fungal infection resulting from too slow drying. Because of the particular dampness of seaweeds, rapid drying is difficult to achieve and frequent (at least once per day) changes of drying-paper are required. In addition, it is helpful to interleave sheets of corrugated cardboard between successive sandwiches of specimens and their accompanying drying papers. Seaweeds are best mounted directly on to the final mounting board to which they generally adhere without the need for gum or gummed paper strips. Small and delicate specimens may be floated on to the mounting board and arranged with the aid of an artist's fine-haired painting brush. For bulky specimens, pressure should be applied sparingly at first and increased to a maximum gradually over a period of three or four days.

Before mounting, all seaweed specimens should be alternately flushed in fresh- and sea-water baths. This practice rids the plants of most of the trapped animals. The final rinse should be in seawater, the salt in which helps to preserve the plants against fungal attack. Data concerning the specimens can be written on the mounting board immediately and should record at least the date and location of the find and the collector's name.

RECOGNITION

Seaweeds are attached plants that are physiologically fully active only while submerged in water more or less conforming chemically to sea-water. There are, however, some seaweed species which thrive in the special conditions of estuaries where sea and fresh waters merge, but the vast majority function best in wholly marine conditions.

Not all attached marine and estuarine plants are seaweeds but only those that belong in the so-called Algae and then only those Algae that are organized into multicellular thalli during at least part of their life-cycle. In practice, this means that seaweeds are usually macroscopic and that five Plant Divisions are involved, namely the Chlorophyta, Phaeophyta, Rhodophyta, Cyanophyta and Chrysophyta. The fact that all marine plants are not seaweeds means that the beginner may easily confuse them with certain flowering-plants and lichens.

Further identification problems arise because not all seaweeds are green; in fact, as often as not, they are brownish, reddish, purplish, yellowish or some other hue more readily associated with animals than with plants. This variety of colours would not in itself cause recognition difficulty, were it not for the occurrence of numerous attached plant-like animals occupying similar habitats.

Animals that the beginner is likely to confuse with plants are sponges, bryozoans, corals, sea-anemones, sea-cucumbers and red-bait. Some of these, like the last three mentioned, can be identified as animals by their reactions when prodded with a blunt instrument – a seaweed merely yields to such a stimulus – but, in other instances, the aid of a hand-lens is needed to discern the multiplicity of tiny creatures crowding the surface of shrub- or fern-like colonial forms, before identification is possible.

The aid of a hand-lens is also required to differentiate a seaweed from either a marine flowering-plant or lichen. In addition to a hand-lens, solutions of cotton blue in lactophenol and acidified aniline sulphate are needed. A freshly exposed section of a seaweed is not stained by either of these solutions, whereas the internal tissue of a lichen is blued by cotton blue and the xylem and other woody elements of flowering-plant organs stain yellow when soaked with aniline sulphate. The coralline Algae with their hard calcareous bodies cannot easily be treated as above; encrusting types, spreading like skins over rocky surfaces, may appear like sponges but their hard, unyielding texture is entirely different. Erect-standing forms differ from the animal corals they resemble by the narrow uncalcified zones that break their surfaces at more or less regular intervals. On the other hand a hand-lens study of a live coral will reveal the presence of numerous individual creatures composing the complex colony.

Relatively crude though these tests may be, they are reasonably reliable.

IDENTIFICATION KEY

The entries here describe any one species in a series of paragraphs. The paragraphs are in pairs which are similarly numbered and each pair represents alternative choices of characteristics. Only one of each pair of paragraphs should apply to any specimen in hand; thus, in paragraphs numbered "1" the specimen is *either* a flowering-plant *or* it is not. Each choice is followed by items which may contain only a numeral, only an identification or both a numeral and an identification. A numeral indicates the paragraphs next to be consulted (excluding all intervening paragraphs) and any identification accompanying a numeral is to be regarded as only partial. A full identification consists of a binomial, the first word of which has a capital initial letter and represents the Genus (compare the Classification Scheme to find its relationships), while the second word is the specific-epithet; further identification may include a subunit of the species, such as subspecies (subsp.) or variety (var.).

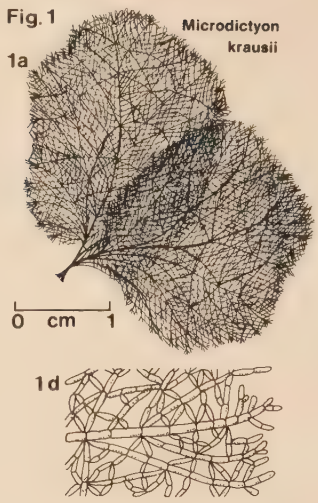
For taxonomic accuracy the name of the author of a binomial should appear; this practice distinguishes the different senses in which a binomial may have been used. A binomial may legitimately (i.e. according to the Rules of the International Code of Botanical Nomenclature of 1972) refer to only one specific entity and its first valid application has priority over all others. For this purpose it is necessary to have a diagnosis and a single reference specimen to represent the type.

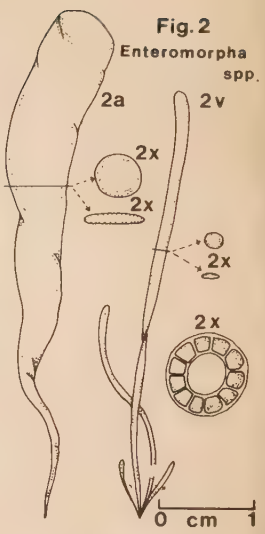
In the present text the authors of binomials are not cited and the bracketed entries which follow the binomials refer, respectively, first, to the accompanying illustrations, and, secondly, to the code for known distribution on the southern African shore; the code is to be interpreted according to the chart provided at the end of the identification key which follows the explanation of the labelling of the numbered Figures.

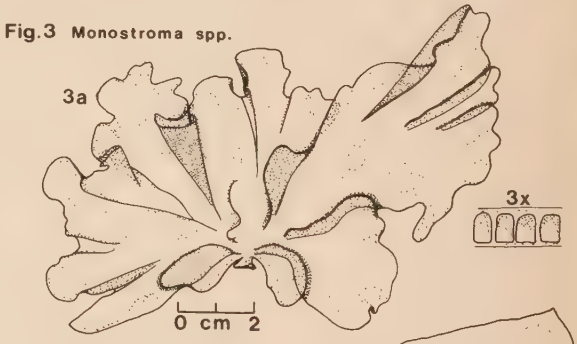
Labelling of Figures

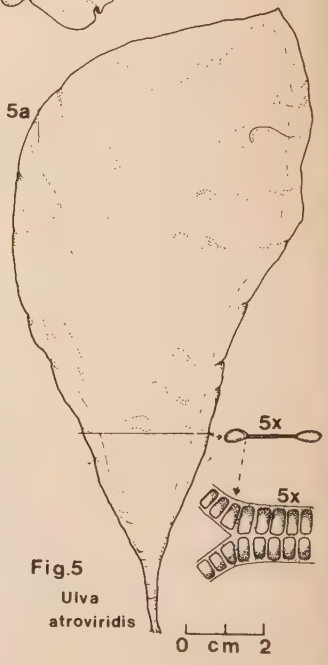
a: general appearance
b: holdfast
c: branch-insertion
cv: variation in branching style
d: details of selected features
dc: detail of a branchlet
h: basiphyte supporting an epiphyte
ha: hair
j: juvenile form
k: sucker
l: lateral appendage
m: detail of margin
r: reproductive tissue or vegetative tissue associated with reproductive structure
s: surface-feature
t: detail of terminal portion of an axis
tv: variation in terminal details
u: utricle
v: variation in gross habit
w: detail of septation
x: detail of transverse section
z: rhizoid

1. Plants green or greenish; growing in sand or mud; vascular bundles present in all organs:
(flowering-plants, not dealt with here)
1. Plants green or not; vascular bundles absent:
2
(seaweeds [or lichens, not dealt with here – see Recognition])
2. Plants green, nowhere tinged with reddish or brownish:
3
2. Plants not as above:
44
3. Thallus membranous, foliaceous, tubular or forming a mesh:
4
3. Thallus not as above:
7
4. Thallus a delicate mesh-like skeleton of a leaf:
Microdictyon krausii
(Fig. 1) (E)
4. Thallus not as above:
5
5. Thallus tubular or collapsed tubular; membrane one cell thick; often irregularly bulbous or trumpet-shaped:
Enteromorpha spp.
(Fig. 2) (A–E)
5. Thallus foliaceous, perhaps tubular at the margins; often like a lettuce leaf:
6
(sea-lettuces)
6. Nowhere tubular; one cell thick:
Monostroma spp.
(Fig. 3) (A–D)
6. Membrane two cells thick, unless tubular at the margin:
Ulva spp.
(Figs. 4 and 5) (A–D)









7. Thallus of forked chains of discs; discs the size of a finger-nail, firmly fleshy:
Halimeda cuneata
(Fig. 6) (D–E)

7. Thallus not as above:
8

8. Thallus fibrous, fan-shaped, above a sub-fibrous stalk:
Udotea orientalis
(Fig. 7) (E)

8. Thallus not as above:
9

9. Thallus bubbly:
10

9. Thallus not bubbly:
11

10. Thallus dissects into club-shaped balloons:
Valonia macrophysa
(Fig. 8) (D)

10. Thallus dissects into tubes:
Valonia aegagropila
(Fig. 9) (D–E)

Fig.6 Halimeda cuneata

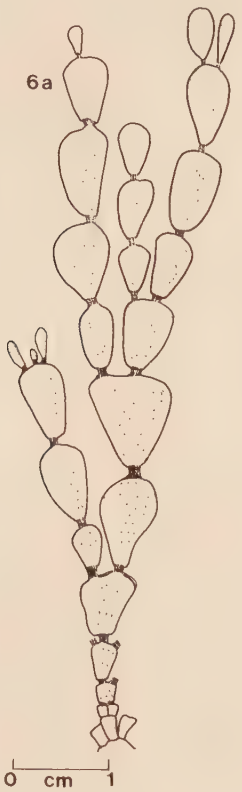


Fig.7 Udotea orientalis

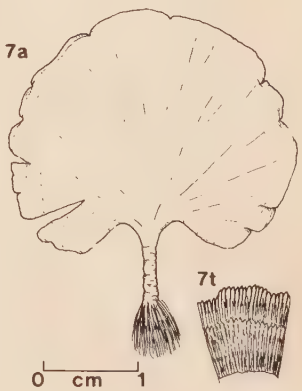


Fig.8 Valonia macrophysa

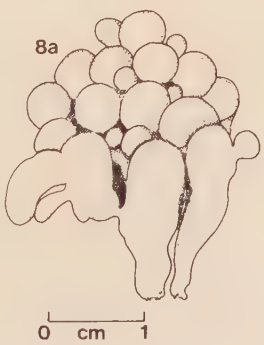
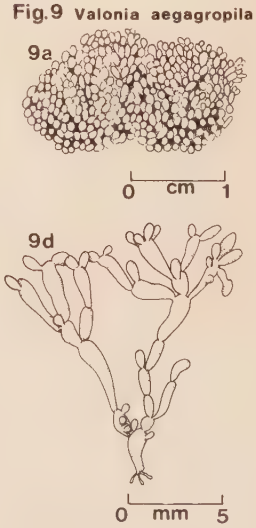


Fig.9 Valonia aegagropila



11. Attachment by clusters of digitate strands spaced at intervals along slender, branched runners:
12

11. Attachment not as above:
14

12. Free parts thin but succulent, grass-like with beaded stalks:
Caulerpa filiformis
(Fig. 10) (B–E)

12. Free parts not as above:
13

13. Free parts like coarse feathers:
Caulerpa holmesiana
(Fig. 11) (B–D)

13. Free parts like small compact bunches of grapes:
Caulerpa racemosa
(Fig. 12) (B–E)

14. Thallus like an artist's paint-brush with a short handle:
Chamaedoris delphinii
(Fig. 13) (E)

14. Thallus not as above:
15

Fig.10 Caulerpa filiformis

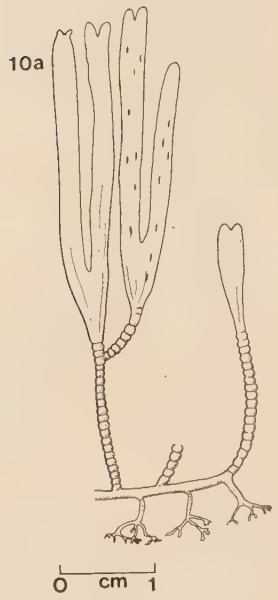


Fig.11 Caulerpa holmesiana

Fig.12 Caulerpa racemosa

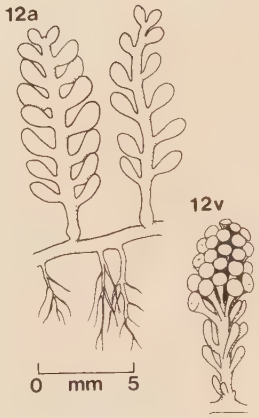
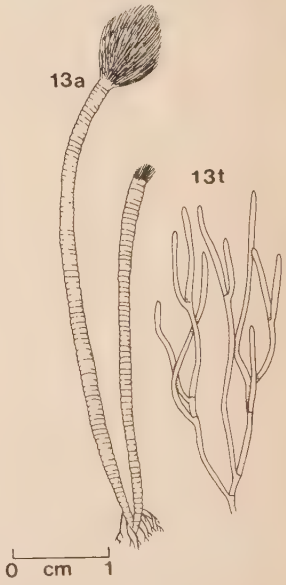


Fig.13 Chamaedoris delphinii



15. Free parts filamentous, more or less translucent:
16

15. Free parts not as above:
28

16. Filaments unbranched, septate:
17

16. Filaments branched:
20

17. Filaments coiling around one another or neighbouring objects; segments up to twice as long as broad:
Chaetomorpha crassa
(Fig. 14) (D)

17. Filaments not as above:
18

18. Segments becoming coarser distally and ultimately almost spherical and up to 2 mm thick:
Chaetomorpha robusta
(Fig. 15) (A–B)

18. Segments slender:
19

19. Basal cell remarkably elongated and stiff; other cells up to twice as long as broad, flaccid:
Chaetomorpha antennina
(Fig. 16) (D)

19. Basal cell not particularly elongated; filaments entirely stiffish:
Chaetomorpha aerea
(Fig. 17) (C–E)

Fig.14 Chaetomorpha crassa

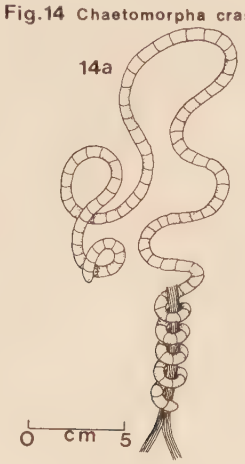


Fig.16
Chaetomorpha antennina

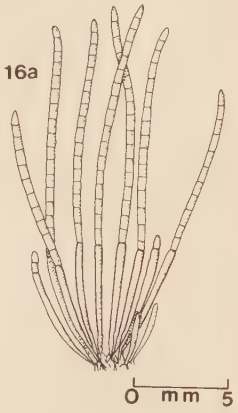


Fig.15 Chaetomorpha robusta

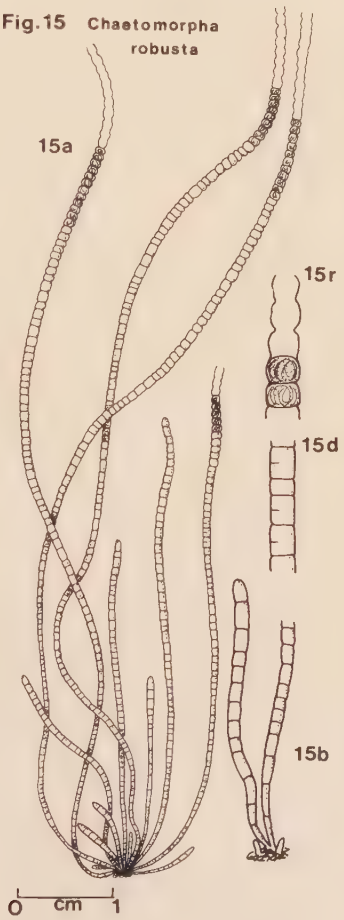
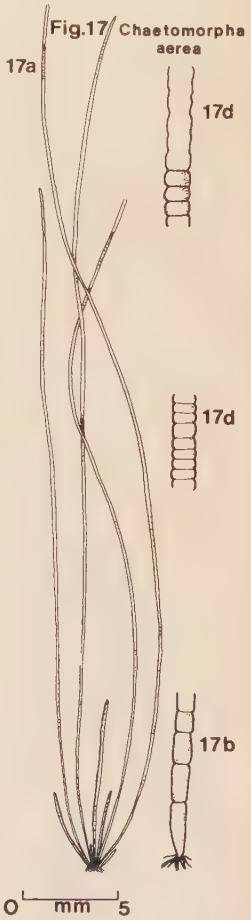


Fig.17 Chaetomorpha aerea



20. Filaments submacroscopically septate (clearly segmented when magnified):
21

20. Filaments aseptate (not segmented):
26

21. Filaments free but compressed into a pile up to 25 mm high:
Cladophora contexta (Fig. 18) (A–B)

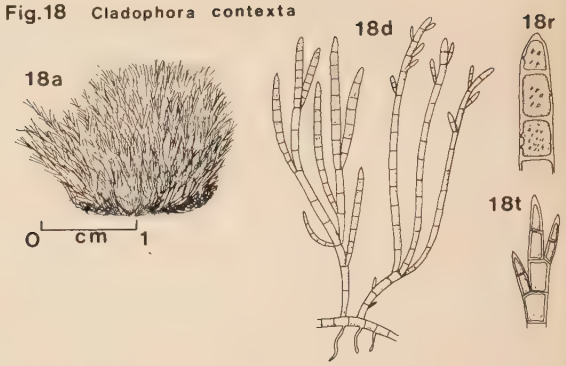
21. Thallus not as above:
22

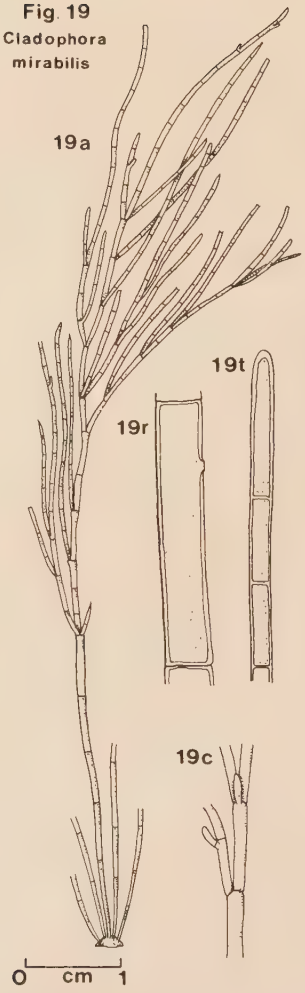
22. Holdfast a tiny disc:
23

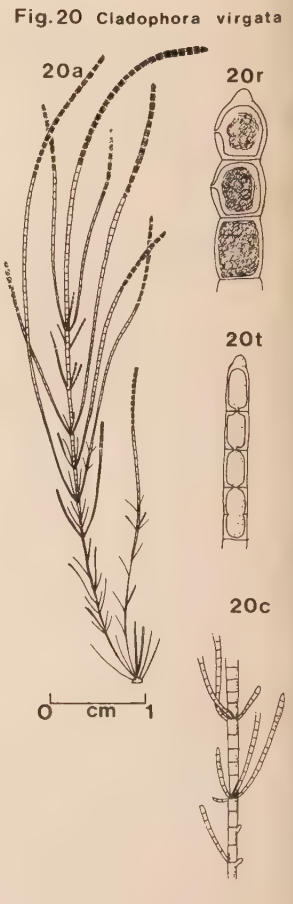
22. Holdfast delicately fibrous:
24

23. Filaments up to 1 mm thick, cylindrical, di- or trichotomously forked at almost all lower septa:
Cladophora mirabilis (Fig. 19) (A)

23. Filaments rarely as much as 0,8 mm thick, dilating gradually from the base, untidily and rather spikily branched; branches tend to arise in whorls:
Cladophora virgata (Fig. 20) (A)







24. Filaments alternately and often profusely branched, slender; branches stiffish, not diverging; segments mostly two to four times longer than broad:

Cladophora capensis
(Fig. 21) (A–B)

24. Filaments di- or trichotomously forked at almost all lower septa; segments often more than six times longer than broad:

25

25. Segments more or less cylindrical but often slightly swollen basally:

Cladophora radiosa
(Fig. 22) (B–C)

25. Segments, at least in lower parts, narrowly truncheon-shaped and faintly annulated in proximal half:

Cladophora rugulosa
(Fig. 23) (C–D)

Fig. 21 Cladophora capensis

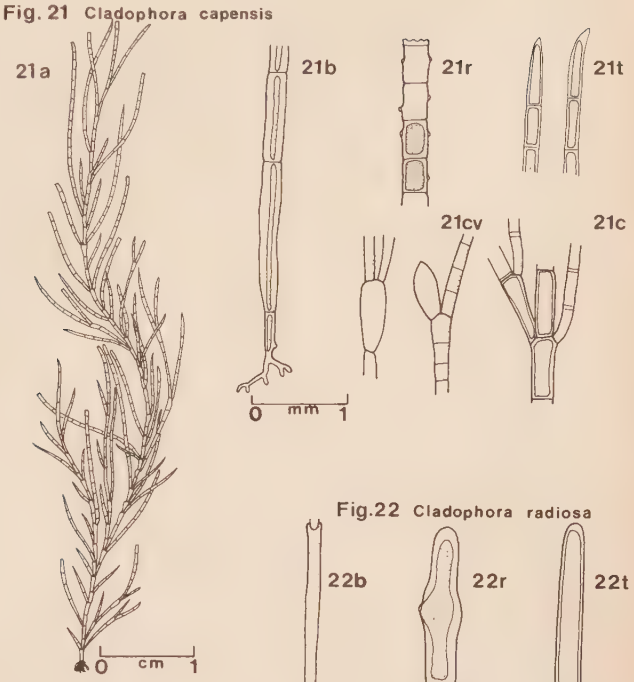


Fig.22 Cladophora radiosa

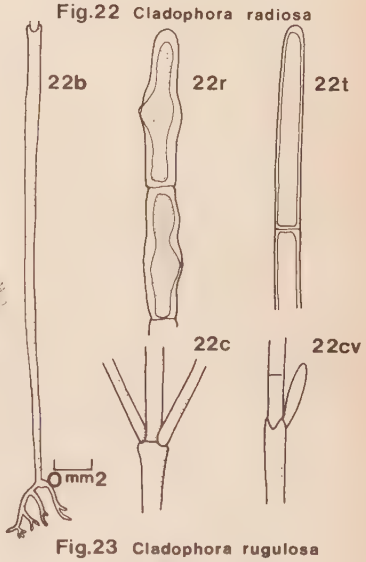
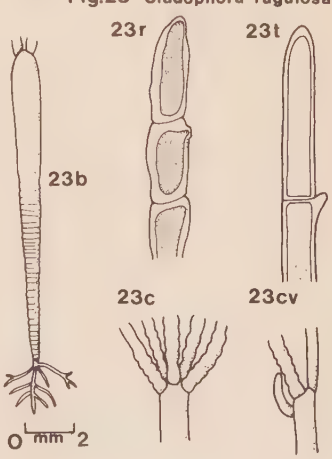


Fig.23 Cladophora rugulosa



26. Thallus a mucilaginous cushion of flaccid, free filaments:

Bryopsis caespitosa
(Fig. 24) (A–B)
Bryopsis africana
(A–B)
Derbesia spp.
(Fig. 25) (A–B)

26. Thallus forming a tuft of more or less erect filaments:

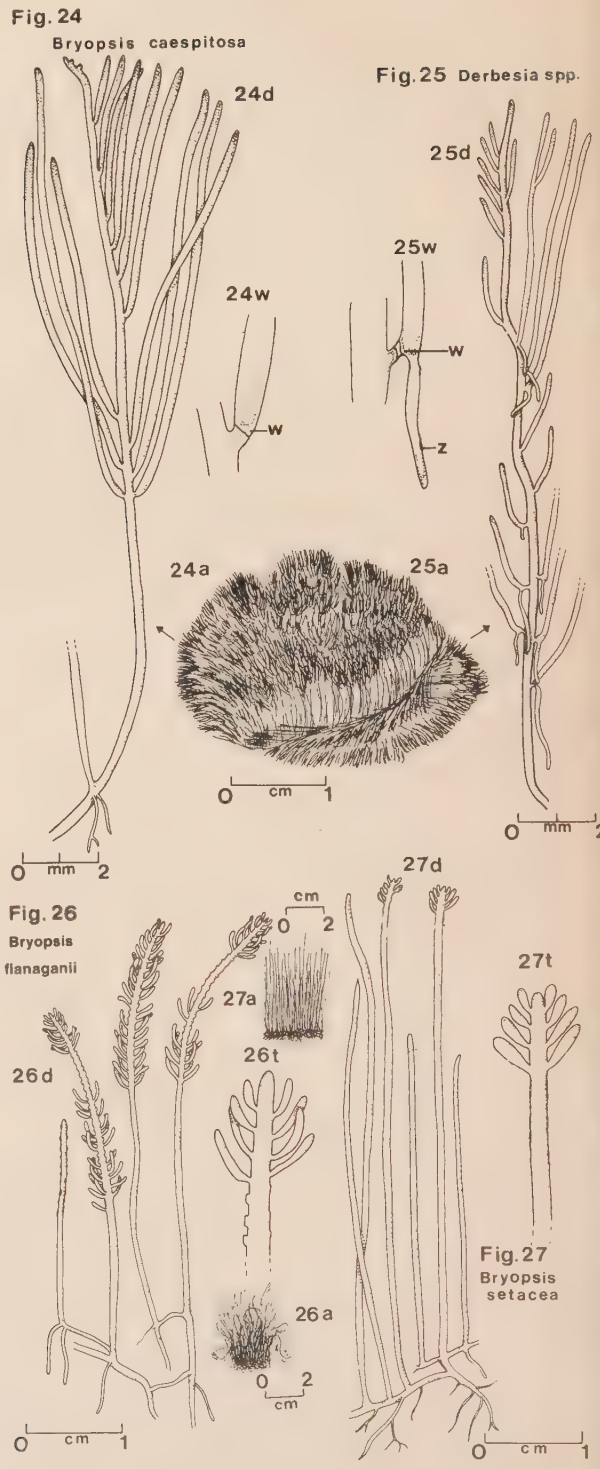
27
(*Bryopsis* spp.)

27. Filaments like flaccid coarse feathers with lower half unpinnated:

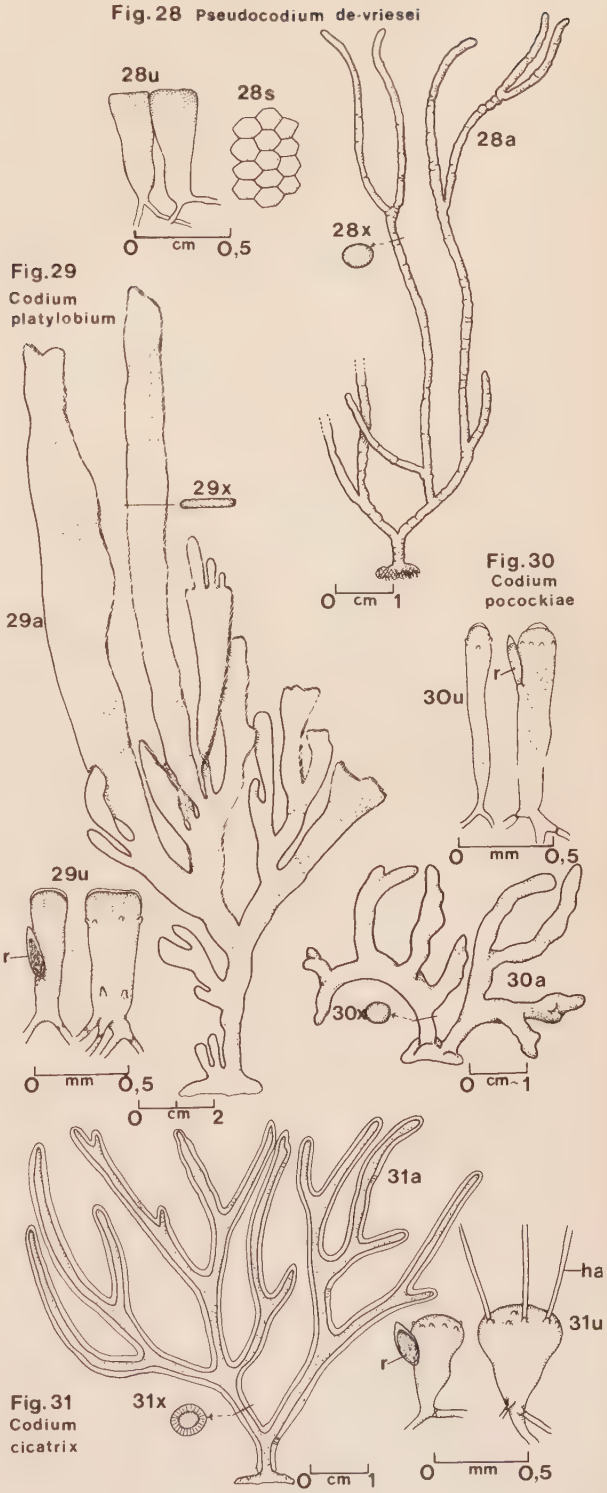
Bryopsis flanaganii
(Fig. 26) (D)

27. Filaments stiffish, not at all featherlike; if pinnated then only at the tip:

Bryopsis setacea
(Fig. 27) (D)



28. Free portions much longer than broad, forking repeatedly:
29
28. Free portions, if present, not much longer than broad:
38
29. Thallus almost fleshy; surface submacroscopically honeycombed with utricles; utricles fused at shoulders:
Pseudocodium devriesei
(Fig. 28) (D–E)
29. Thallus almost spongy; surface not obviously honeycombed but utriculate; utricles free at shoulders:
30
(*Codium* spp.)
30. Axes broadly flattened, up to 2 000 mm long, forking irregularly:
Codium platylobium
(Fig. 29) (D–E)
30. Not as above:
31
31. Forks of unequal length; thallus of staghorn shape:
Codium pocockiae
(Fig. 30) (E)
31. Forks approximately equal:
32
32. Thallus, at least terminally, with translucent edges:
33
32. Thallus not as above:
34
33. All edges translucent:
Codium cicatrix
(Fig. 31) (E)



33. Translucent terminally only; axes slender except at dichotomies:
Codium tenue
(Fig. 32) (D)

34. Utricles capped with a spine:
Codium fragile subsp. *capense*
(Fig. 33) (A–C)

34. Utricles not as above:
35

35. Utricles rarely as long as 1 mm; not growing east of the Cape of Good Hope on the Cape Peninsula:
Codium isaacii
(Fig. 34) (A)

35. Utricles if shorter than 1 mm then on plants growing east of the Cape of Good Hope or in Saldanha Bay:
36

36. Utricles often longer than 1 mm; axes substantial with broadly rounded tips, cylindrical or compressed:
Codium duthieae
(Fig. 35) (B–D)

36. Utricles rarely longer than 1 mm; axes slender and cylindrical or tapering distally to 2 mm thickness:
37

Fig. 32 Codium tenue

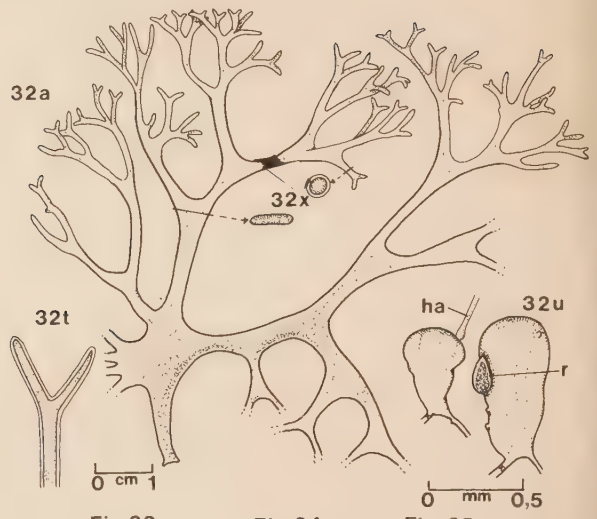
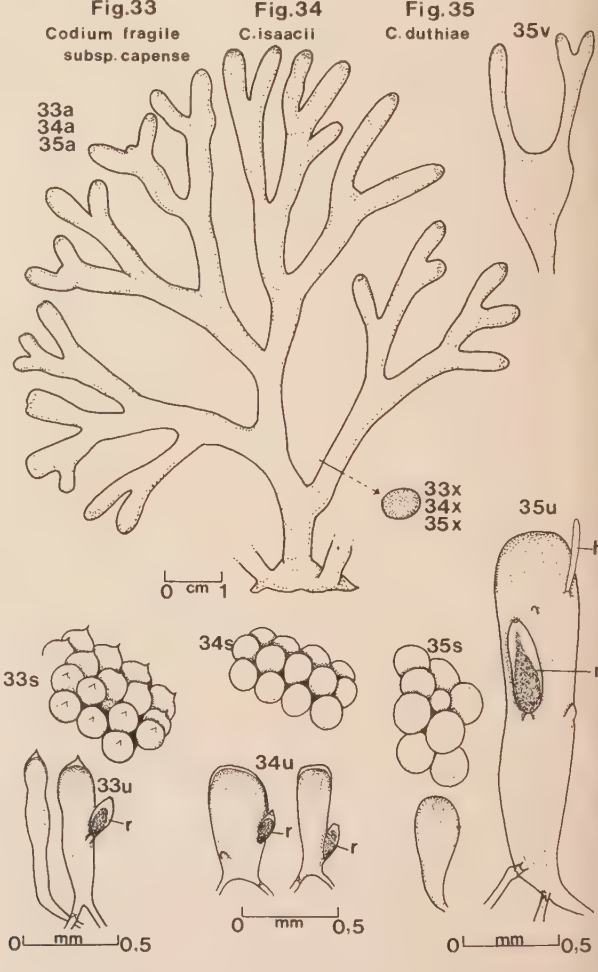


Fig.33 Codium fragile subsp. capense

Fig.34 C.isaacii

Fig.35 C. duthiae



37. Axes uniformly slender, sometimes constricted at close intervals of 2 mm to 4 mm:
Codium capitatum
(Fig. 36) (D–E)

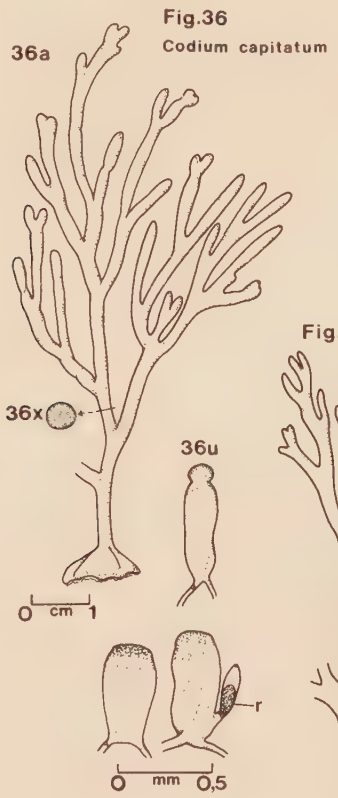
37. Axes tapering distally:
Codium extricatum
(Fig. 37) (C–E)

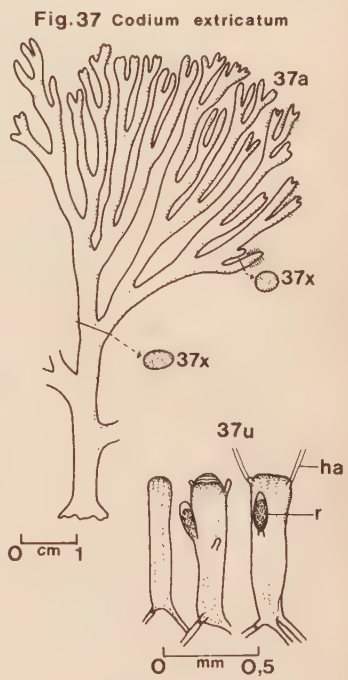
38. Axes subcylindrical, creeping, dichotomizing at close intervals:
Codium prostratum
(Fig. 38) (D–E)

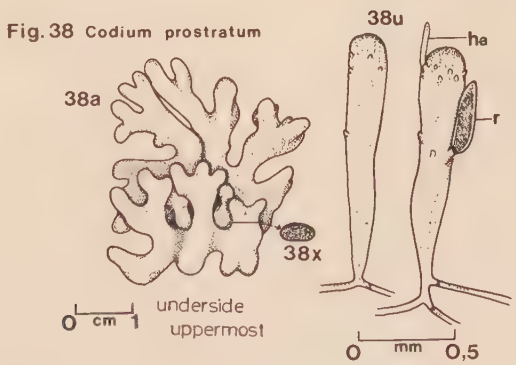
38. Axes not distinguishable:
39

39. Thallus more or less globose:
40

39. Thallus irregularly lobed or spreading more or less thickly on the substratum:
41







40. Utricles submacroscopic, compacted into an uninterrupted surface; thallus often dished at the top:
Codium papenfussii
(Fig. 39) (B–D)

40. Utricles macroscopic, loosely aggregated:
Codium megalophysum
(Fig. 41) (A–C)

41. Thallus almost free of the surface, splitting into ear-like lobes:
Codium stephensiae
(Fig. 41) (A–C)

41. Thallus closely adherent:
42

42. Thallus skin-like and often discontinuous:
Codium pelliculare
(Fig. 42) (C)

42. Thallus fleshy:
43

43. Thallus remaining intact when stored in fluid preserve:
Codium lucasii subsp. *capense*
(Fig. 43) (C–E)

43. Thallus gelatinizing when stored in fluid preserve:
Codium spongiosum
(Fig. 44) (D–E)

Fig. 39 Codium papenfussii

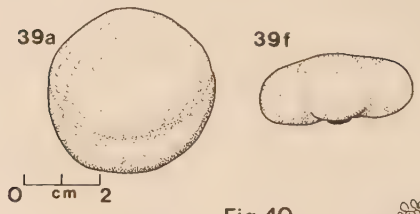


Fig. 40
Codium megalophysum

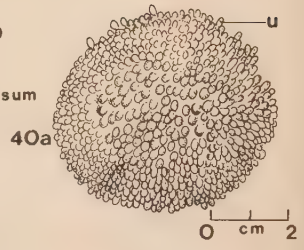


Fig. 41 Codium stephensiae

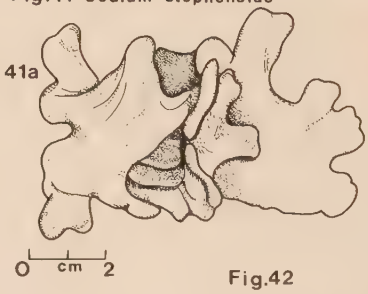


Fig. 42
Codium pelliculare

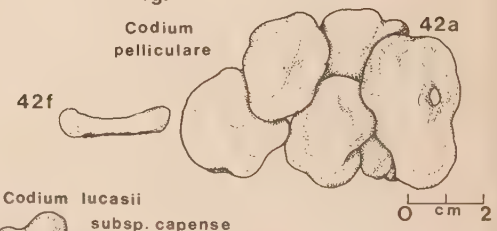
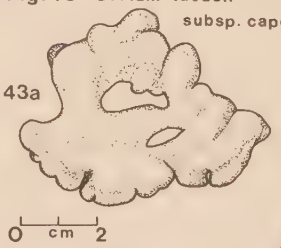


Fig. 43 Codium lucasii subsp. capense



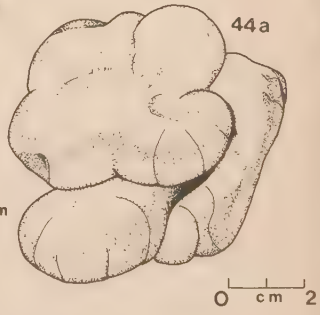


Fig. 44
Codium spongiosum

44. Free axes more or less bright green, slenderly cylindrical; basal portions slenderly rhizomatous, discoloured purplish:

45

44. Free axes not bright green:

46

45. Ultimate laterals short and thorn-like and often crowded into a brush-like cluster on one side of the parent-axis:

Hypnea spicifera
(Figs. 45 and 158) (A–D)

45. Ultimate axes not as above; axes intertwined into a loose tangle:

Hypnea viridis
(Fig. 46) (D)

46. Leathery brown spindle-shaped bladders:

Chaetangium ovale
(Fig. 47) (A–C)

46. Not as above:

47

47. Free parts fleshy, more or less boat-shaped, liberally ornamented with short fleshy processes; attachment by fleshy narrow runners; dark purple:

Gigartina stiriata
(Figs. 48, 113 and 128) (A–B)

47. Thalli not as above:

48

Fig. 45
Hypnea spicifera

Fig. 46
Hypnea viridis

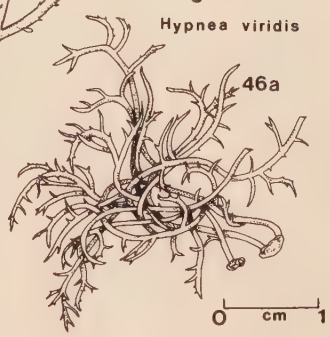


Fig. 47
Chaetangium ovale

Fig. 48
Gigartina stiriata

48. Thallus of smooth or knobbly cushions:
49

48. Not as above:
51

49. Thin- and smooth-skinned balloons, frequently epiphytic; yellowish:
Colpomenia sinuosa
(Fig. 49) (A–C)

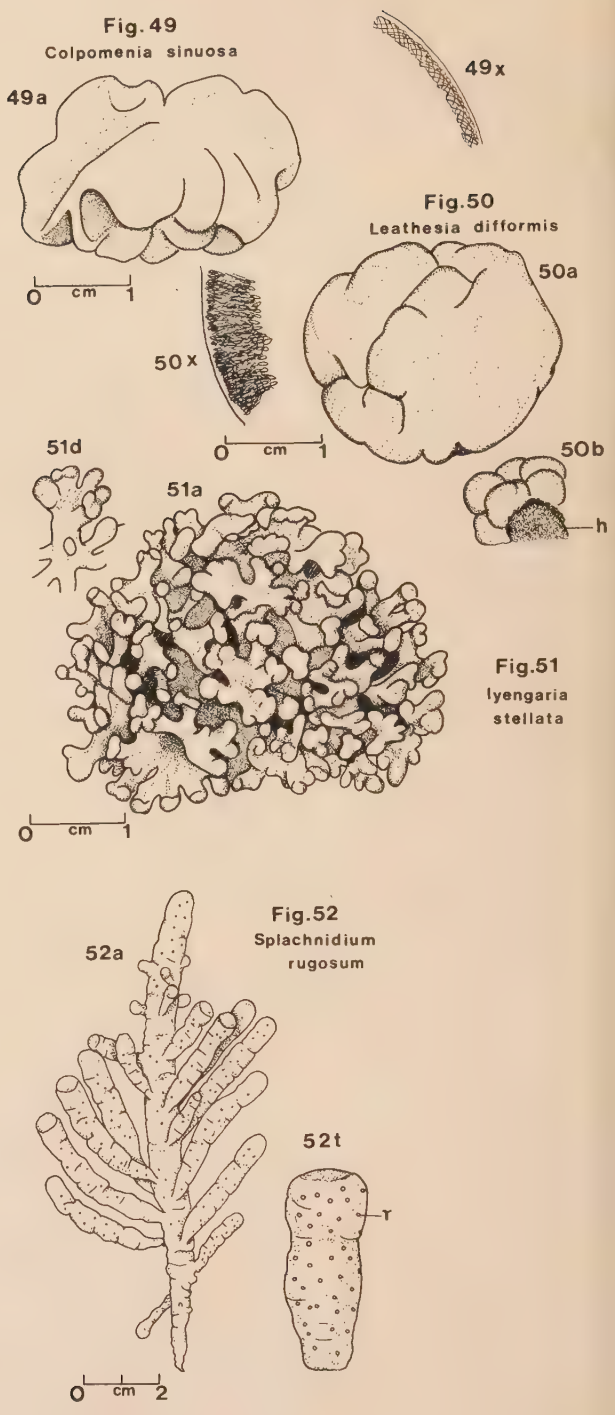
49. More or less solid, fleshy:
50

50. Surface more or less smooth; frequently epiphytic:
Leathesia difformis
(Fig. 50) (A–D)

50. Surface ornamented with knobs; not epiphytic:
Iyengaria stellata
(Fig. 51) (B–D)

51. Free parts like withered and calloused fingers, branched; branches sometimes berry-like; internally filled with clear viscous mucilage; brown:
Splachnidium rugosum
(Fig. 52) (A–D)

51. Not as above:
52



52. Holdfast fist-sized or larger with numerous intertwining horny branches; stipes elongated to substantial organs; leafy parts providing extensive surface area:

53

52. Not as above:

56

53. Stipe trunk-like, single, tapering gradually upwards; blade palmate splitting distally into strap-like segments; yellowish brown:

Laminaria pallida
(Fig. 53) (A)

53. Not as above:

54

54. Stipe trunk-like, single, dilating upwards gradually at first then swelling rapidly into a club-shaped bulb; leafy organs numerous, strap-shaped, supported on a horny, flat, diamond-shaped tongue atop the stipe; brown:

Ecklonia maxima
(Fig. 54) (A–B)

54. Not as above:

55

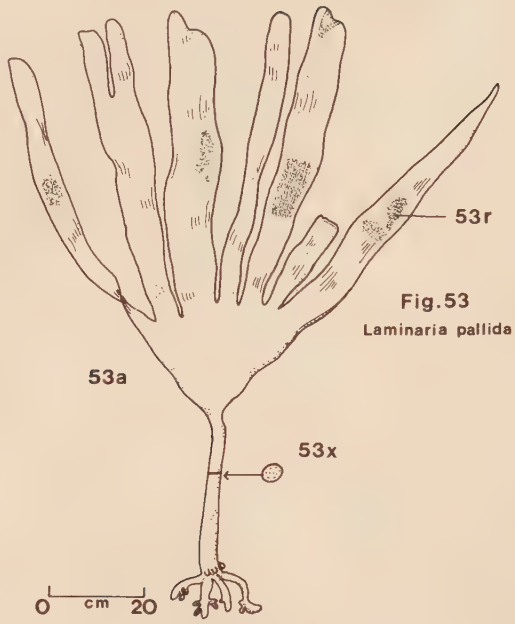


Fig.53
Laminaria pallida

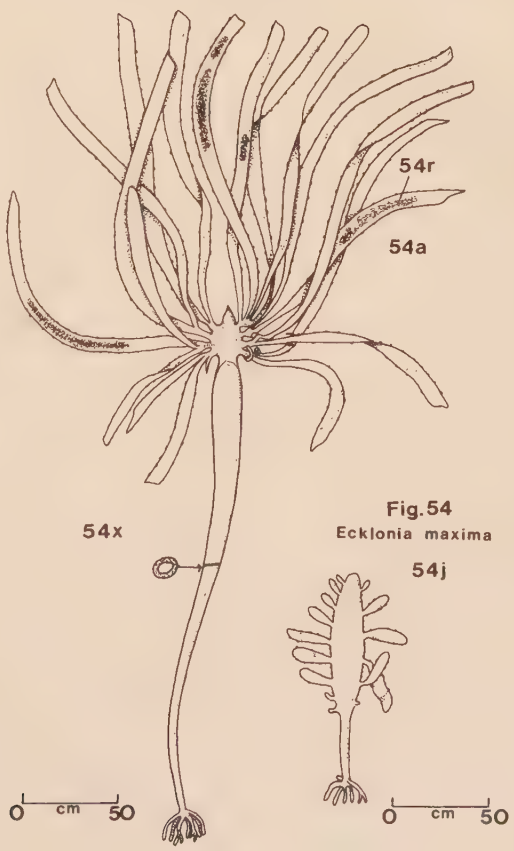
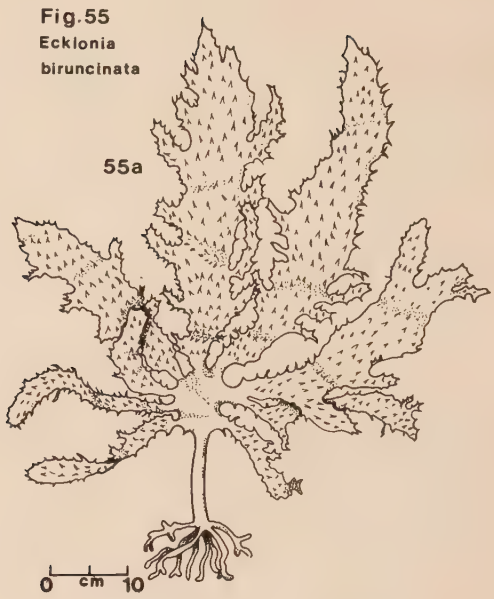
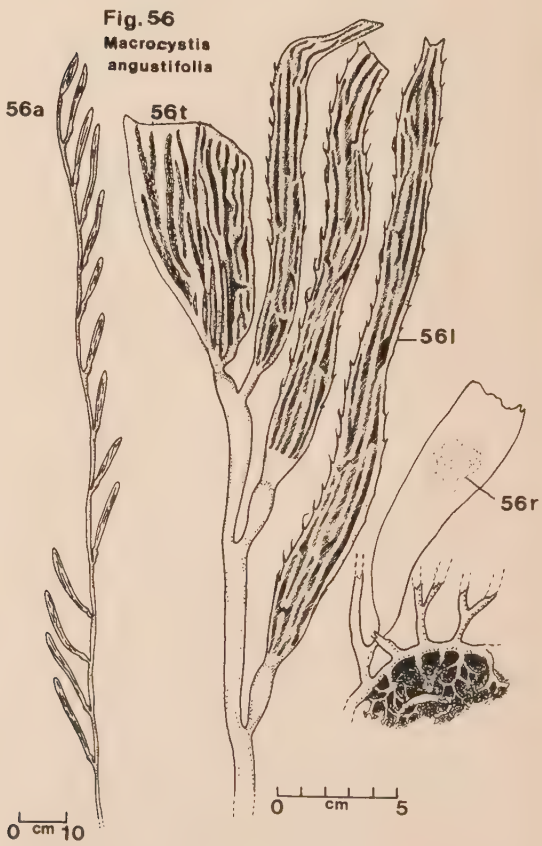


Fig.54
Ecklonia maxima



55. Stipe single, trunk-like but short, tapering slightly upwards; leafy organs horribly but harmlessly spiny, supported on a small, horny tongue topping the stipe; dark brown:
Ecklonia biruncinata
(Fig. 55) (C–D)

55. Stipes many, vine-like, bearing numerous "leaves" singly at almost regular intervals which shorten distally; "leaves" with stalked basal bladder; yellowish brown:
Macrocystis angustifolia
(Fig. 56) (A)



56. "Leaves" narrow, leathery, spurred like thistle leaves, forming a basal rosette; attachment by radiating creeping stalks; when fertile, carrying one or perhaps more erect central stalks bearing close spirals of trumpet-shaped bladders and short tuberculous branches; brown:
Turbinaria ornata
(Fig. 57) (D–E)

56. Not as above:
57

57. Free parts of fan-shaped lobes sometimes much lacerated, usually bearded in basal parts; neither reddish nor purplish; often concentrically if obscurely banded:
58

57. Not as above:
61

58. Fans brown, encrusted with lime, strongly banded, terminally rolled under:
Padina spp.
e.g: *P. commersonii*
(Fig. 58) (D–E)

58. Not as above:
59

59. Fans short, lobed deeply, more or less rigidly membranous, spreading and suspended more or less horizontally; yellowish brown:
Homoeostrichus multifidus
(Fig. 59) (B–C)

59. Not as above:
60

60. Fans large, usually much lacerated, banded, patently when young but obscurely when old, also dark and corrugated when old:
Stypopodium zonale
(Figs. 60 and 111) (C–D)

Fig. 57
Turbinaria ornata

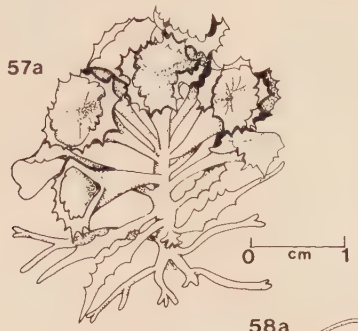


Fig. 58
Padina commersonii

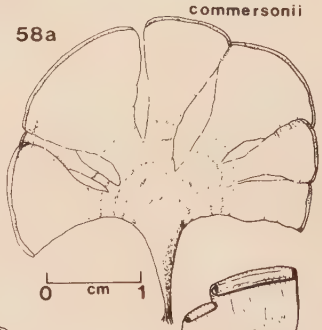


Fig. 59
Homoeostrichus multifidus

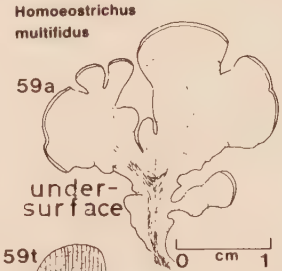
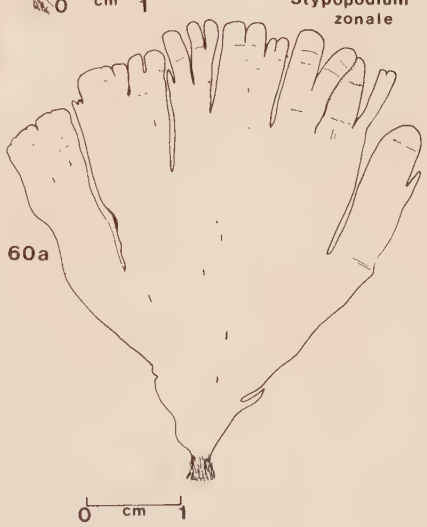


Fig. 60
Stypopodium zonale



60. Fans membranous, more or less erect, compound and overlapping; yellowish brown:
Zonaria tournefortii
(Fig. 61) (D)

61. Axes up to 10 mm wide, thin and leathery, linear, erratically and bilaterally branched, discoloured and arched at the distal margin, banded to some extent, bearded below; dark brown:
Zonaria subarticulata
(Fig. 62) (B–D)

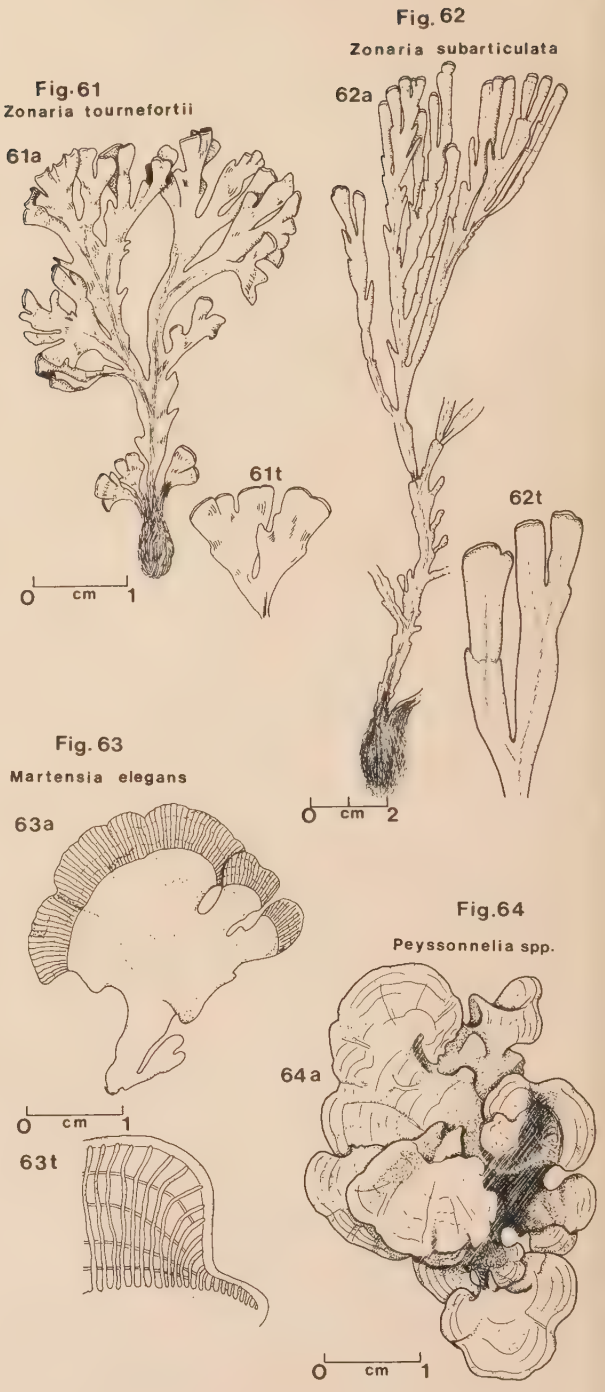
61. Axes not as above but perhaps fan-shaped:
62

62. Fan fleshy, flaccid, broadly and concentrically zoned alternately into meshwork and solid sections; warty reproductive excrescences may appear on bars of the mesh; mauve, iridescing to yellowish:
Martensia elegans
(Fig. 63) (D–E)

62. Not as above:
63

63. Fans leathery, white on underside and purple above, zonately ridged, suspended horizontally:
Peyssonnelia spp.
(Fig. 64) (D–E)

63. Not as above:
64



64. Not free of the substratum:

65

64. Substantially free:

69

65. Thallus porcelain-like:

lithothamnia
encrusting corallines
(Fig. 65) (A–E)
e.g. *Lithothamnion* spp.,
Lithophyllum spp.,
Dermatolithon spp.,
Melobesia spp.

65. Not as above:

66

66. Crusts very thin, leathery, adherent on other seaweeds, notably *Codium platylobium* (Fig. 29), have appearance of blood stains:

Placophora binderi
(Fig. 66) (B–D)

66. Not as above:

67

67. Crusts olive-brown or darker with zonate ridging, sometimes pustulate; margins yellow and arched in segments:

Ralfsia expansa
(Fig. 67) (A–D)

67. Crusts blood-red or purplish; margins not regularly arched:

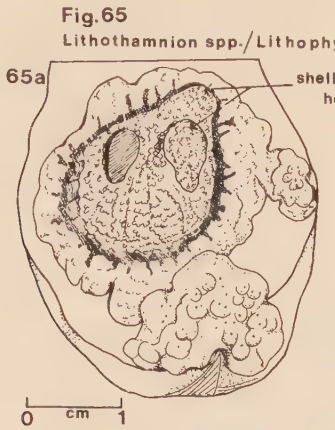
68

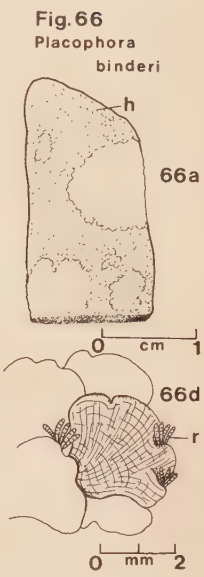
68. Crusts friable and lifting at the margins; surface pustulate:

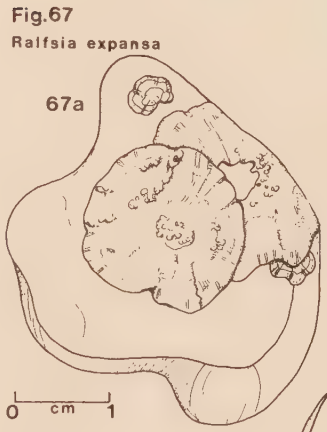
Hildenbrandia pachythallos
(Fig. 68) (A–C)

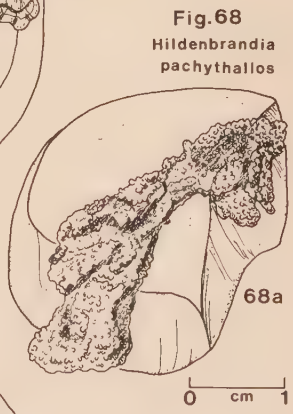
68. Crusts membranous, appearing like blood stains:

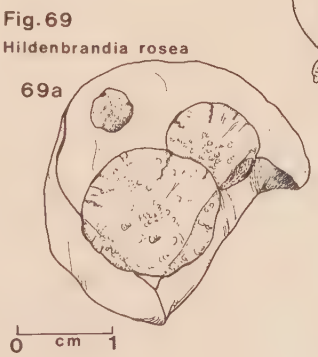
Hildenbrandia rosea
(Fig. 69) (B–D)











69. Axes porcelain-like and jointed:
70
(articulated corallines)

69. Not as above:
79

70. Branching dichotomous throughout:
71

70. Branching mainly pinnate:
78

71. Joints between segments obvious; segment surfaces warty:
72

71. Joints between segments as hair-lines; segment surfaces smooth:
75

72. Segments flat, knife-edged; joints ornamented with nodules:
Amphiroa bowerbankii
(Fig. 70) (C–D)

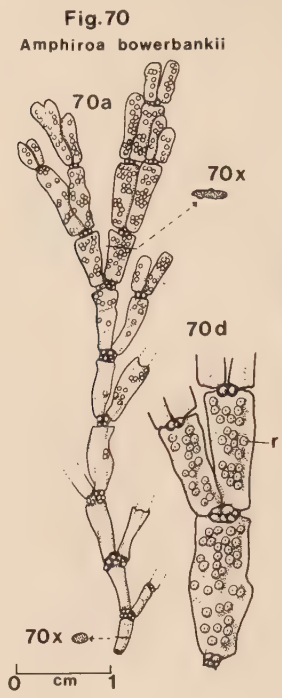
72. Not as above:
73

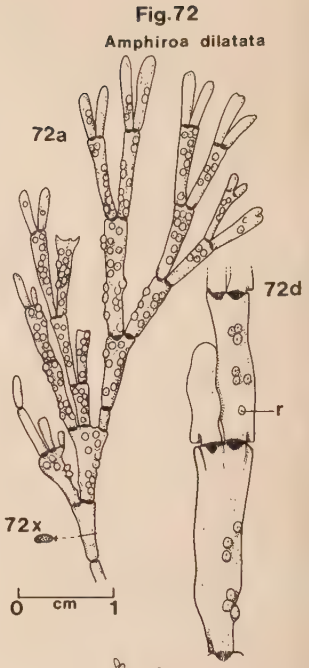
73. Segments cylindrical or compressed, up to 1 mm thick:
Amphiroa ephedraea
(Fig. 71) (B–D)

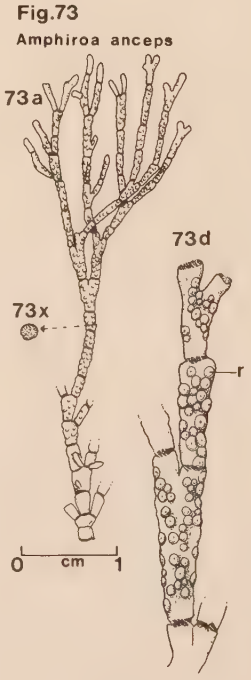
73. Segments flat:
74

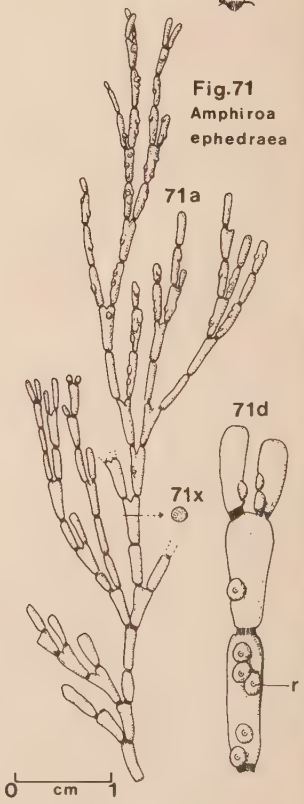
74. Shoulders of segments project forwards as teeth:
Amphiroa dilatata
(Fig. 72) (D)

74. Shoulders of segments smooth:
Amphiroa anceps
(Fig. 73) (C–D)









75. Segments cylindrical, slender; fertile segments swollen, opening by an axillary pore: *Jania* spp. (Fig. 74) (A–E)

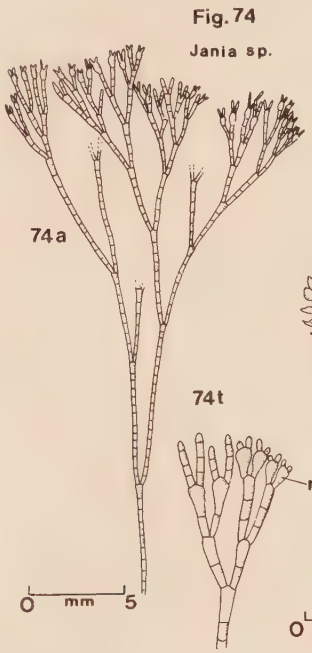
75. Segments bilaterally winged; fertile segments swollen, opening on forward edges: 76 (*Cheilosporum* spp.)

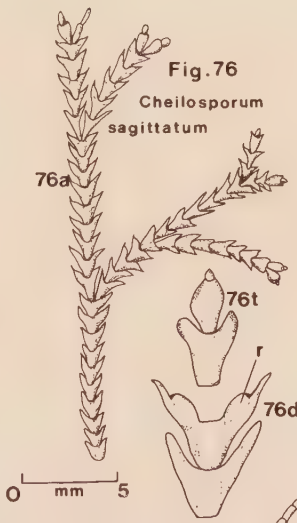
76. Segments crescent-shaped; fertile segments with one to three swellings on each wing: *Cheilosporum cultratum* (Fig. 75) (B–D)

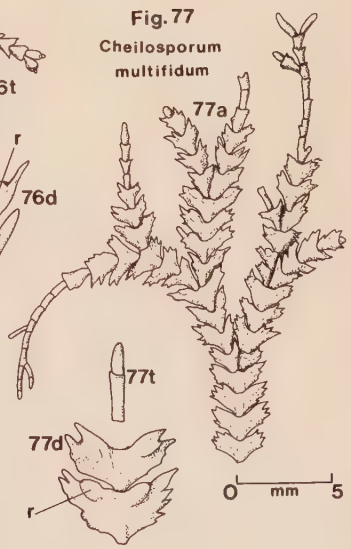
76. Not as above: 77

77. Segments like arrow-heads: *Cheilosporum sagittatum* (Fig. 76) (D)

77. Segments have irregular edges: *Cheilosporum multifidum* (Fig. 77) (C–D)







78. All branching pinnate; fertile segments terminal, club-shaped or provided with two horns:
Corallina spp.
(Fig. 78) (A–E)

78. Fertile segments form dichotomizing chains:
Arthrocardia spp.
(Fig. 79) (A–D)

79. Axes sinuous and extremely flaccid, branched, pencil-thick, richly furry with olive-brown or golden-brown hairs; hairs free or embedded in mucilage:
Papenfussiella spp.
(Fig. 80) (A–B)
Myriogloea spp.
(Fig. 81) (A–B)
Myriocladia capensis
(A–B)
Levringia spp.
(A–B)

79. Not as above:

80

Fig. 78
Corallina sp.

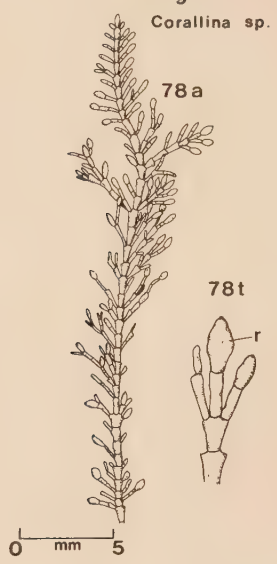


Fig. 79
Arthrocardia sp.

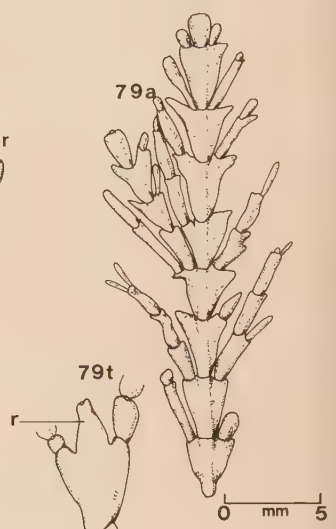
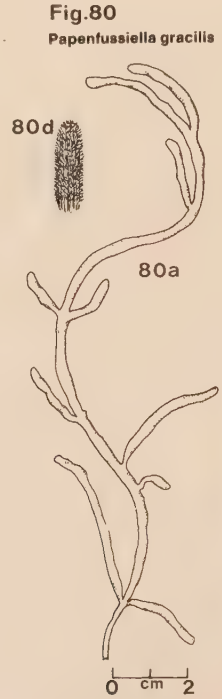


Fig. 80
Papenfussiella gracilis



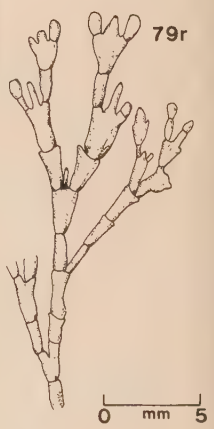


Fig. 81
Myriogloea sp.

80. Foliaceous or foliose; fronds either more or less simple or compounded into few or many, broad or narrow strap-like parts, if narrow then linear in section, with or without stipes, sometimes ribbed and/or veined:

81

80. Neither foliaceous nor foliose; fronds, if present, scarcely different from stipes, narrow and either circular or elliptical in section:

134

81. Fronds leathery, linear, about 10 mm wide with distinct midrib and short stipe, alternately and bilaterally branched, flexed at each node, chocolate-brown; fertile fronds truncated terminally, armed with marginal compound papillae; holdfast conical and horny:

Carpophyllum scalare
(Fig. 82) (A–B)

81. Not as above:

82

82. Stipe percurrent bearing lateral leafy parts, bladders and slender or stunted fertile axillary branch-systems; brown:

83

82. Not as above:

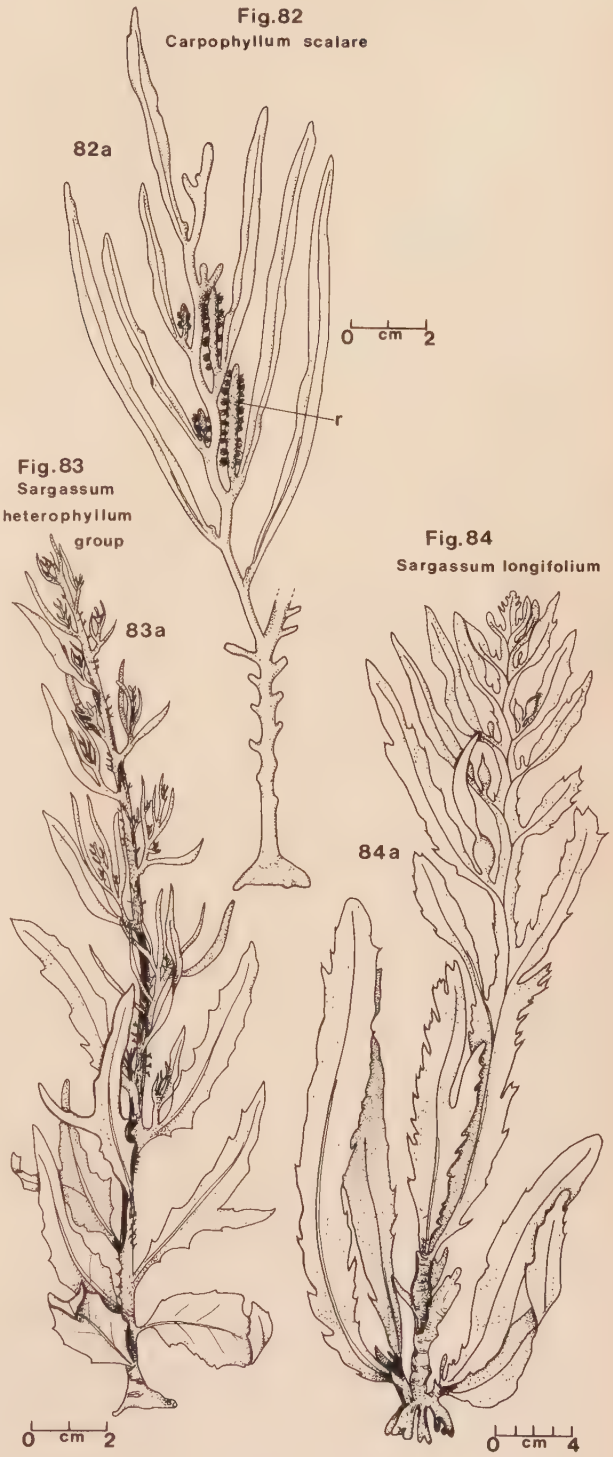
84

83. Lower "leaves" ovate, up to 80 mm long and 25 mm wide, with toothed margins; upper "leaves" of each stipe narrow, linear, smooth-margined; fertile branches often inconspicuous:

Sargassum heterophyllum-group
(Fig. 83) (B–D)

83. All "leaves" elongated, often compound, toothed or delicately spurred at margins; fertile branches delicate and elongated:

Sargassum longifolium
(Fig. 84) (B–D)



84. Stipe penetrating leafy parts as a midrib, bearded at the base; brown:
85

84. Stipe, if penetrating leafy parts, not bearded:
88

85. "Leaf"-margins more or less continuous:
86

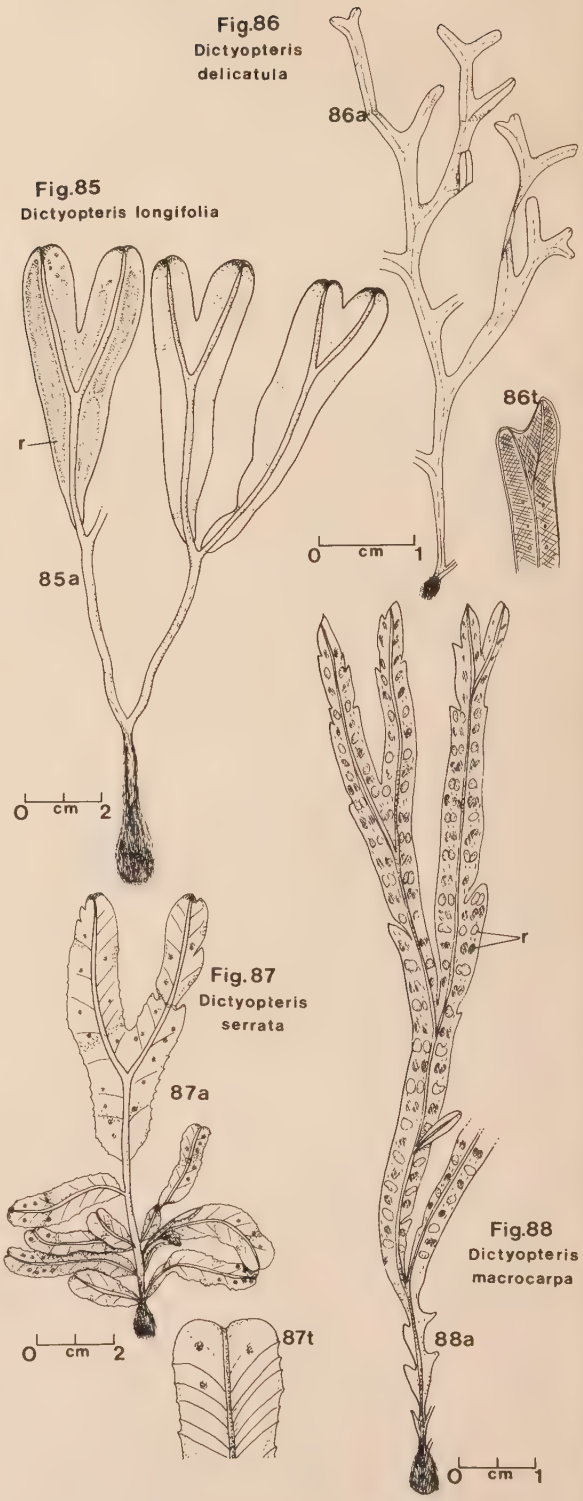
85. Not as above:
87

86. Frond dichotomizing almost regularly at 50 mm intervals, ultimate lobes elongated; wings missing in lowest one or two dichotomies:
Dictyopteris longifolia
(Fig. 85) (C–D)

86. Frond dichotomizing almost regularly every 10 mm, substipitate:
Dictyopteris delicatula
(Fig. 86) (D–E)

87. "Leaf"-margins toothed; "leaves" delicately veined, dichotomously forked; veins oblique to margins:
Dictyopteris serrata
(Fig. 87) (D–E)

87. "Leaf"-margins smooth except where torn or where proliferating; leafy parts forking irregularly, streakily discoloured and, when fertile, decorated with two to four longitudinal rows of ovate patches of sori:
Dictyopteris macrocarpa
(Fig. 88) (D–E)



88. Stipe more or less percurrent through entire plant:
89

88. Not as above:
92

89. Midrib well defined throughout:
90

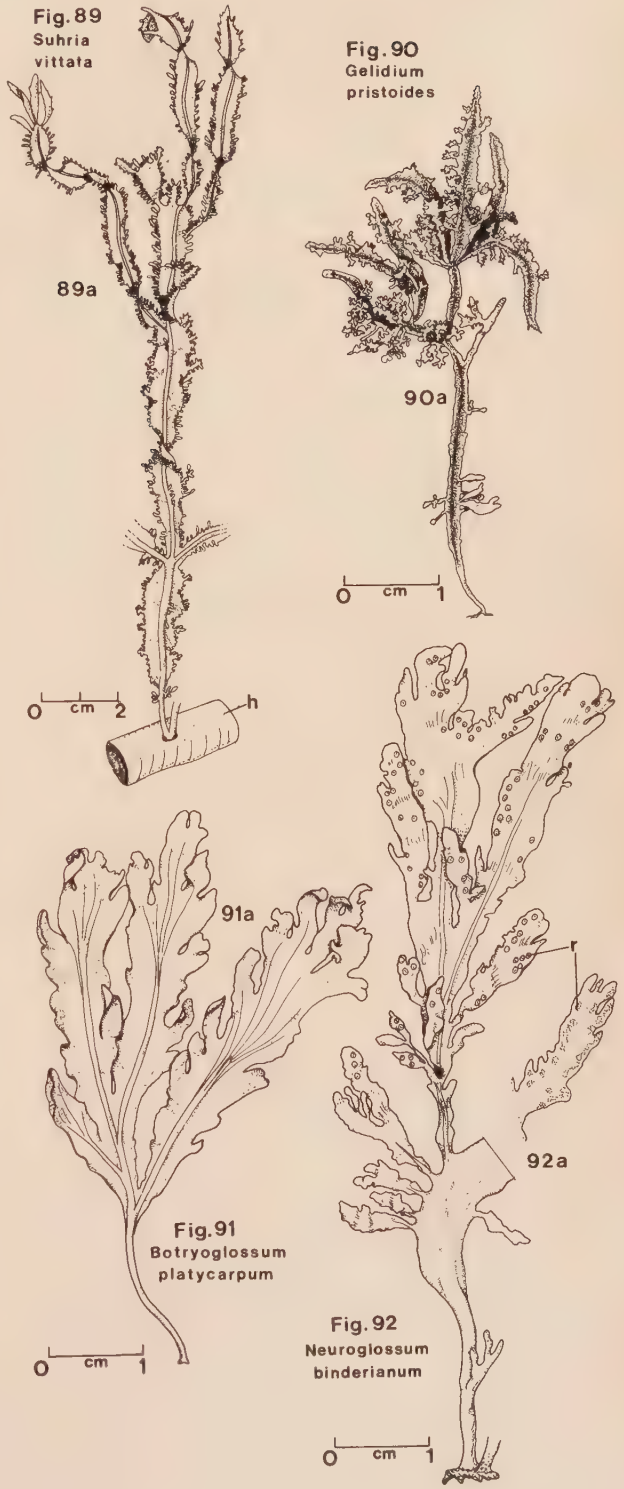
89. Midrib not always well defined, ends subterminally:
91

90. Most often epiphytic on *Ecklonia maxima* (see Fig. 54), sometimes on shellfish, rarely on rock; margins decorated with a frill of delicate "leaflets" interspersed with larger proliferations; midrib often armed with membranous teeth; purple:
Suhria vittata
(Fig. 89) (A–B)

90. Most often on rock or shellfish; margins finely serrated; brownish purple:
Gelidium pristoides
(Fig. 90) (B–D)

91. Midrib fans out into delicate veins ultimately; membranous wings more or less broken into individual segments having rounded distal margins; purple:
Botryoglossum platycarpum
(Fig. 91) (A)

91. Midrib not as above; membranous wings as in *B. platycarpum* above but often carrying diminutive "leaflets" at the margins; purple:
Neuroglossum binderianum
(Fig. 92) (A)



92. Blades permeated by several coarse, subparallel, slightly sinuous, branched veins, forked; iridescing purple:
Hymenena venosa
(Fig. 93) (A)

92. Not as above:
93

93. Plant small, creeping over other plants; stipes slender and wiry, haphazardly forked; "leaves" delicate and uniformly moulded, forward edge consisting of three or four teeth, backward edge almost straight, obscurely and reticulately veined; purple:
Polyzonia elegans
(Fig. 94) (C–D)

93. Not as above:
94

94. Fronds macroscopically saw-edged except at the tip where teeth are folded inward to make a hood; veining sometimes obscure:
95

94. Not as above:
97

95. Blades slightly concavo-convex; teeth on the two margins opposite; vein often prominent down middle of convex surface; dark purple:
Kuetzingia natalensis
(Fig. 95) (D–E)

95. Blades contorted at regular intervals or in a lax spiral; teeth on the two margins alternate:
96

96. Stipe short; blades twisted in a lax spiral; teeth minutely compound; brownish purple:
Dictymenia stephensonii
(Fig. 96) (D–E)

Fig. 93
Hymenena venosa

Fig. 94
Polyzonia elegans

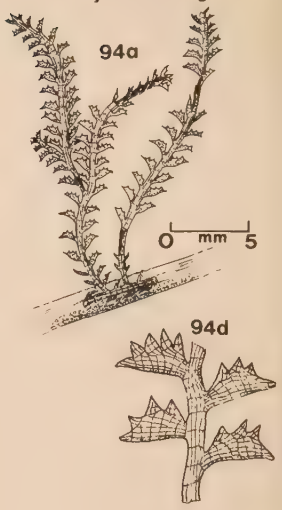


Fig. 95
Kuetzingia natalensis

Fig. 96
Dictymenia stephensonii

96. Stipe slenderly trunk-like, twisted in a lax spiral, forked once or twice; blades elongated, forked, twisted through 180° at regular intervals involving a succession of four marginal teeth; teeth smaller at the contortions; dark purple:

Vidalia serrata
(Fig. 97) (D)

97. Fronds with marginal lobes grouped so that two succeeding members on one side alternate with similar members on the other; the lower appendage of each group is simple and claw-like:

98

97. Not as above:

99

98. Claw-like lobes up to 10 mm wide at their bases and bearing microscopically compound marginal teeth; reproductive structures form on appendages in tiny superficial rosettes of "leaflets"; reddish purple:

Plocamium corallorhiza
(Fig. 98) (A–D)

98. Claw-like lobes less than 5 mm wide at their bases and sometimes bearing simple marginal teeth; reproductive structures on appendages form in minute axillary branchlets; reddish purple:

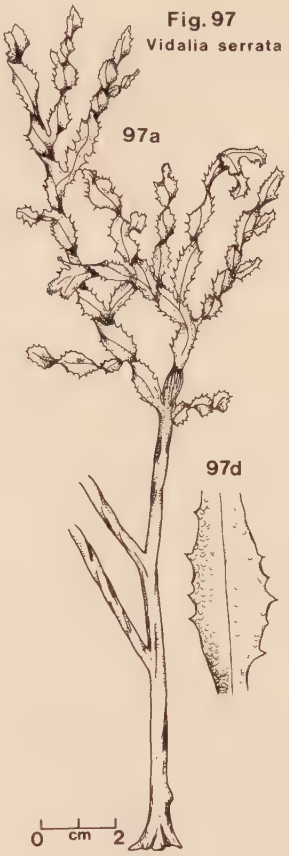
Plocamium suhrii
(Fig. 99) (B–D)

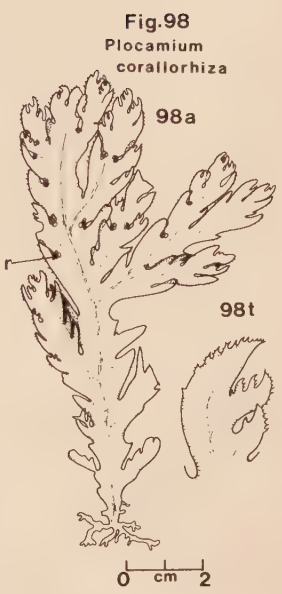
99. Blades with finely serrated margins, uniformly wide (about 10 mm), thin but fleshy, dichotomizing erratically; substipitate; purple:

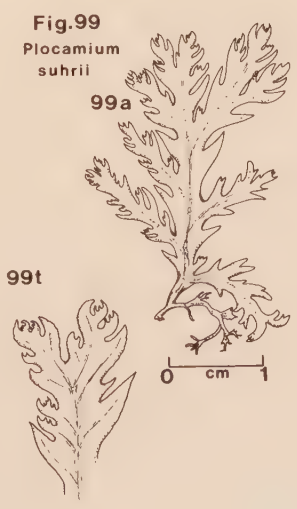
Gracilaria beckeri
(Fig. 100) (C–D)

99. Not as above:

100







100. Fronds repeatedly but not dichotomously branched; margins smooth, or much frilled or profusely proliferating; thallus lacking extensive terete portions:
101

100. Fronds more or less simple or dichotomously forking:
104

101. Axes apically turned in to be minutely hooded and digitate; branching alternate and repeated; branches of same order not overlapping but graded so that longest is medially placed; purple:
Chondrococcus hornemannii
(Fig. 101) (C–D)

101. Not as above:
102

102. Axes elongated, elliptic, narrow, thin and scarcely fleshy; main axis branched at right-angles; longest branches proximal and again branched; brownish purple:
Grateloupia filicina
(Figs. 102 and 153) (A–B)

102. Not as above:
103

103. Plant epiphytic on *Ecklonia maxima* (see Fig. 54); main axis elongated, profusely and haphazardly branched; thallus thin but fleshy, flaccid; purple:
Carpoblepharis flaccida
(Figs. 103 and 152) (A–B)

103. Plant not epiphytic, broad and linear, forking once palmately or sometimes dichotomously; margins frilled or proliferating; fleshy; reddish purple:
Calliblepharis fimbriata
(Fig. 104) (C)

Fig.101
Chondrococcus hornemannii

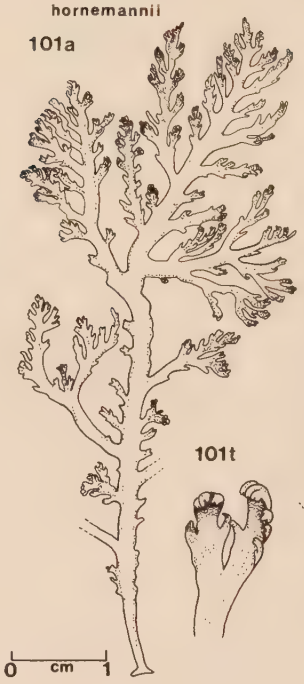


Fig.102
Grateloupia filicina

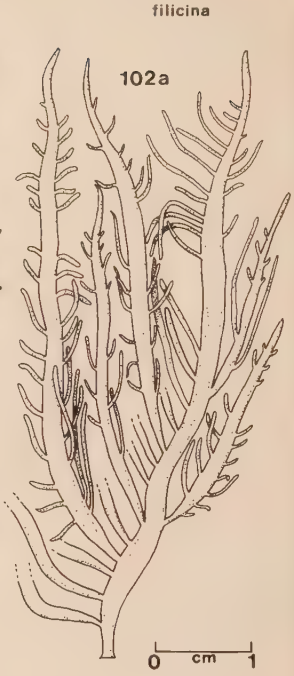


Fig.103
Carpoblepharis flaccida

Fig.104
Calliblepharis fimbriata

104. Plant red, entirely membranous and foliaceous, mostly one cell thick, substipitate, less than 50 mm high, permeated by sinuous microscopic veins:

105

(*Acrosorium* spp.)

104. Not as above, but if membranous and one cell thick then straw-coloured or blackish, more than 50 mm high and not at all veined:

107

105. Irregularly lobed; lobes tapering distally often to coiled extremities:

Acrosorium uncinatum
(Fig. 105) (B–C)

105. More or less dichotomously lobed:

106

106. Discoloured with pale blotches:

Acrosorium maculatum
(Fig. 106) (B–C)

106. Not as above:

Acrosorium acrospermum
(Fig. 107) (B–C)

107. Plant a more or less simple, flaccidly crispate blade, mucilaginous, nowhere cylindrical or narrowed into stipe-like portion:

108

107. Plant not as above:

110

108. Membranous, mucilaginous and flaccid when fresh, friable when dried, one cell thick, almost black with discoloured margins (east of Cape Agulhas frond tends to be straw-coloured); holdfast insignificant:

Porphyra capensis
(Fig. 108) (A–D)

108. Rubbery, not membranous, horny when dried; holdfast a callus:

109

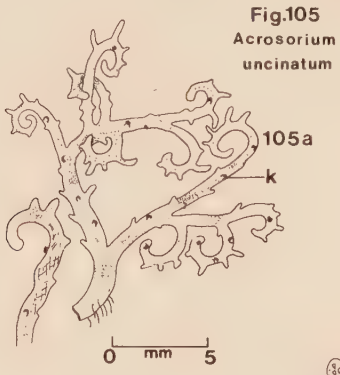


Fig.105
Acrosorium
uncinatum

Fig.106
Acrosorium
maculatum

Fig.107
Acrosorium
acrospermum

Fig. 108
Porphyra
capensis

109. Olive-brown or purplish, thick, simple or lobed, up to 1 500 mm long and almost as wide; margins smooth except proximally where they are rough; surfaces delicately and reticulately patterned:

Aeodes orbitosa
(Fig. 109) (A–C)

109. Reddish purple, thin, haphazardly perforated and armed with teeth on all margins; margins often two-lipped:

Pachymenia cornea
(Figs. 110 and 132) (A–C)

Fig.109
Aeodes orbitosa

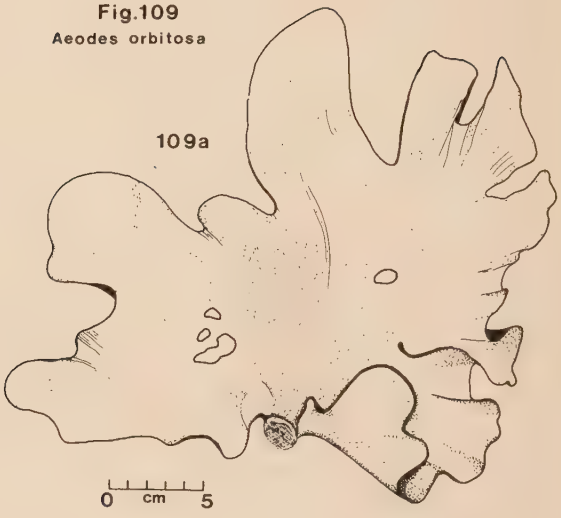
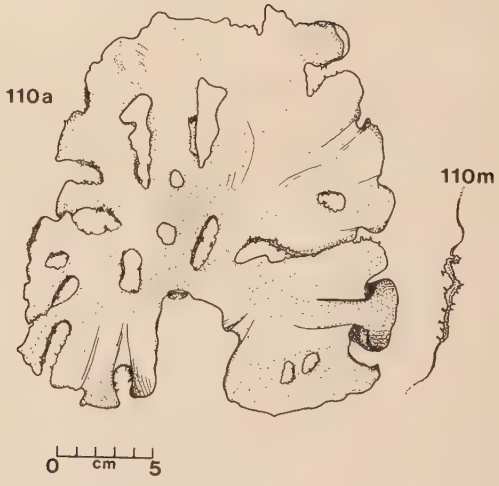


Fig.110
Pachymenia cornea



110. Plant brown or blackish; holdfast bearded, knob-like; stipe short, bearded; blade brokenly lobed into strap-like segments, thin and leathery; surfaces markedly corrugated:

Stypopodium zonale
(Figs. 111 and 60) (C–D)

110. Not as above:

111

111. Thallus simple, but perhaps shredded, or forking di- or trichotomously:

112

111. Thallus lobed or branched, not forking:

122

112. Axes flattened, estipitate or substipitate, di- or trichotomizing repeatedly and frequently, mauve, 2–10 mm wide:

112A

112. Not as above:

113

112A. Axes di- or trichotomizing, elongated, thin but fleshy, lightly banded, having a tough pellicle impregnated with lime, 5–10 mm wide, constricted at irregular intervals; adorned with blackish-purple whorls of hairs at the base and at some constrictions:

Galaxaura diessingiana
(Fig. 112) (C–D)

112A. Axes dichotomizing closely and in one plane to form squat fans, thin but tough, 2–5 mm wide, not noticeably constricted, glabrous, purplish red with reddish apices:

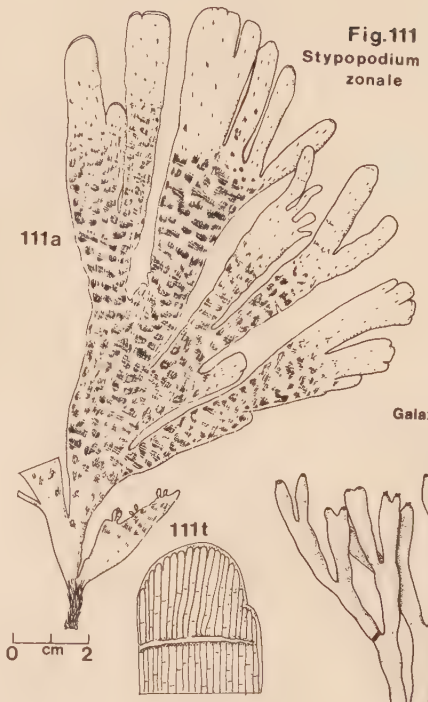
Trematocarpus scutellatus
(Fig. 112.5) (A–C)

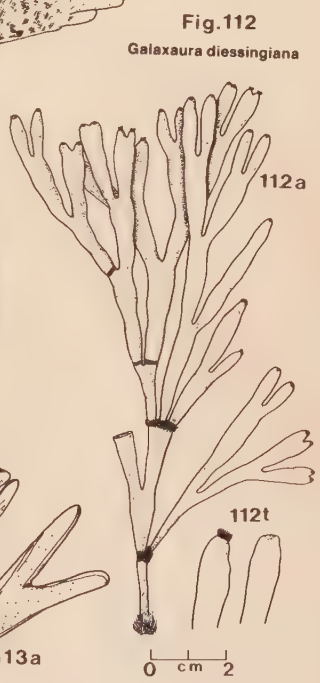
113. Fronds firm, fleshy, shaped like forked tongues; margins thickened slightly, when fertile covered with black freckles; very dark purple:

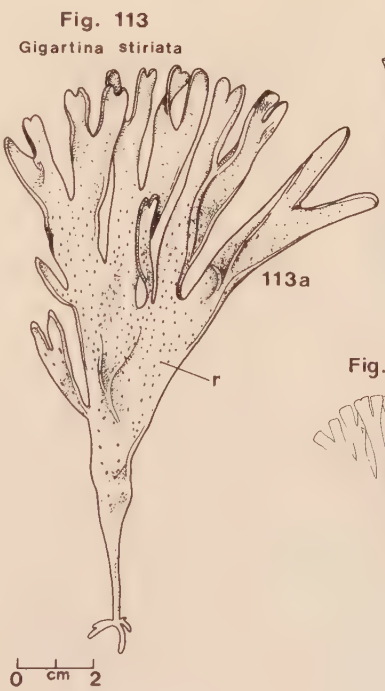
Gigartina stiriata
(Figs. 113, 48 and 128) (A–B)

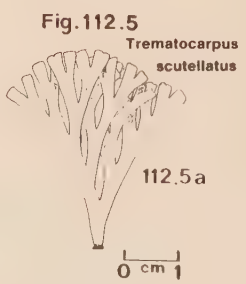
113. Not as above:

114









114. Blades thin, mucilaginous, fleshy, shaped like forked tongues; forked fairly regularly at 50 mm intervals; stipe cylindrical, succulent; purplish red:

Nemastoma lanceolata
(Fig. 114) (A)

114. Not as above: **115**

115. Blade recti- or curvilinear, simple (perhaps torn into two strips), mucilaginous; stipe simple, relatively short; holdfast insignificant or relatively substantial and compounded into branching haptera; plants brown: **115A**

115. Blade more or less repeatedly dichotomizing: **116**

115A. Holdfast insignificant; blade almost membranous, up to 100 mm long and 25 mm wide:

Petalonia fascia
Endarachne binghamiae
(Fig. 115) (A–D)

115A. Holdfast of branching haptera; blade somewhat leathery, may be transversely rippled, up to 300 mm long and 60 mm wide: juvenile forms of:

Ecklonia maxima
Laminaria pallida
Macrocystis angustifolia
(A–C)

116. Holdfast and stipe unadorned: **117**

116. Holdfast and stipe bearded; frond light brown but often iridescing under water: **121**

(*Dictyota* spp.)

117. Blades almost parchment-like, di- or trichotomously forked at irregular intervals; stipes elongated, cylindrical or compressed: **118**

117. Blades more or less leathery, regularly dichotomous, fanning out from a short, flat or cylindrical stipe, ultimately notched at the apices; purple: **120**

118. Blades strap-shaped, forked once or twice; lobes more than 10 mm wide; stipe often forked once; if fertile, blade having scattered rosettes of tiny leaflets; coppery:

Epymenia obtusa
(Fig. 116) (A–B)

118. Not as above, blades forked repeatedly; lobes less than 10 mm wide: **119**

119. Thallus purplish-red; stipe entirely cylindrical; fertile areas scarcely distinct:

Rhodymenia spp.
e.g. *R. natalensis*
(Fig. 117) (A–D)

Fig 114 Nemastoma lanceolata

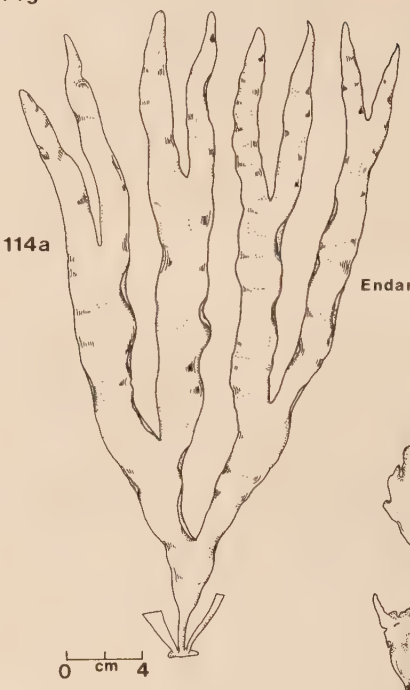


Fig.115
Endarachne binghamiae/
Petalonia
fascia

Fig.116
Epymenia obtusa

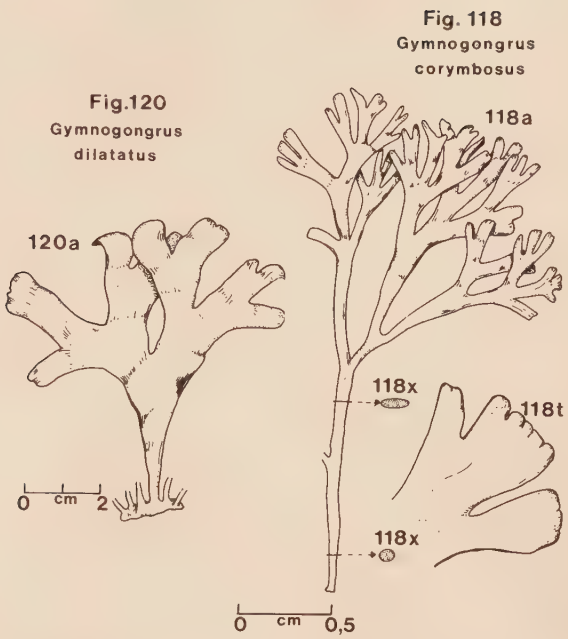
Fig.117
Rhodymenia natalensis

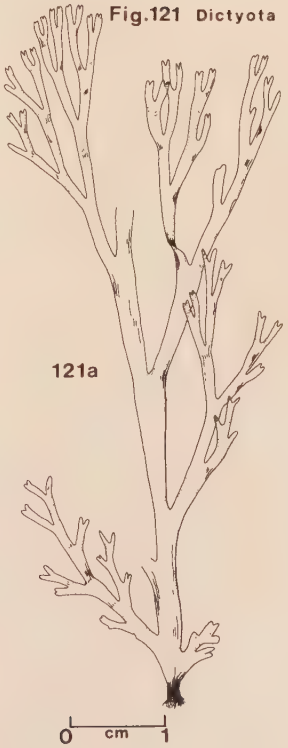
119. Thallus dark purple; stipe proximally cylindrical then becoming compressed; if fertile ornamented with warty blisters:
Gymnogongrus corymbosus
(Fig. 118) (A)

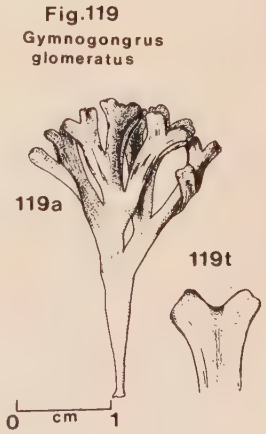
120. Lobes less than 5 mm wide; thalli clustering into dense, low stands up to 80 mm high and 50 mm across; individuals fan-like, arching somewhat; purple:
Gymnogongrus glomeratus
(Fig. 119) (A–B)

120. Lobes wider than 5 mm; thalli not much clustered, up to 150 mm high; individuals not much arched except terminally; purple:
Gymnogongrus dilatatus
(Fig. 120) (A–B)

121. Thallus up to 10 mm wide; lobes very flaccid, matted, membranous, uniformly pigmented:
Dictyota dichotoma
(Fig. 121) (B–E)







121. Thallus broader than 10 mm; lobes slightly elliptical, flaccid, membranous, streaked with discolourations:

Dictyota naevosa
(Fig. 122) (B–D)

122. Blades thin, leathery, often with tattered margins usually unlobed but with marginal proliferations; fertile areas in tiny rosettes of leaflets on blade-surfaces; stipes branched; coppery turning sooty on exposure to air:

Botryocarpa prolifera
(Fig. 123) (A)

122. Not as above:

123

123. Blades with erupting papillae or teeth on surfaces:

124

123. Not as above:

128

124. Eruptions papilloid, numerous or scattered, tab-like; blades thin, leathery, flaccid, up to 100 mm wide and 300 mm long, lobed, brownish purple:

Chaetangium erinaceum
(Fig. 124) (A–C)

124. Eruptions either tooth-like or fleshy:

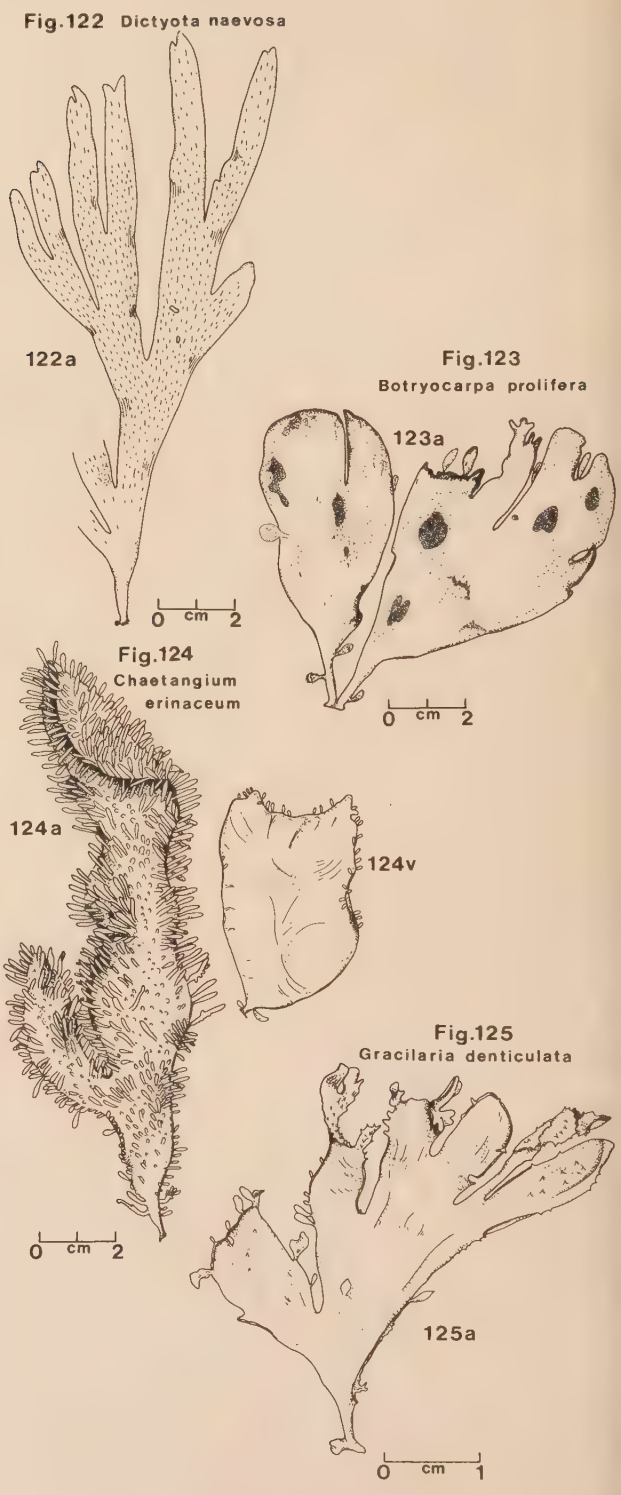
125

125. Teeth tiny, commonly in distal parts only; margins toothed or papillate; blades irregularly lobed, less than 100 mm long; stipe short; purple shot with green:

Gracilaria denticulata
(Fig. 125) (C)

125. Not as above:

126



126. Papillae numerous, small and knob-like, about 1 mm in diameter; blades simple, elliptic or oval, rubbery, stipitate; holdfast a laterally expanded disc becoming slender, succulent, runner-like; purple:
Gigartina radula
(Fig. 126) (A–B)

126. Papillae fleshy and tab-like:
127

127. Blades slightly elliptic, about 20 mm wide, not much lobed, terminating sometimes in two horn-like projections; eruptions numerous; purple or brownish:
Gigartina paxillata
(Fig. 127) (C)

127. Blades lance-shaped, up to 20 mm wide, not much lobed, slightly concavo-convex; margins thickened; eruptions few and scattered; purple:
Gigartina stiriata
(Figs. 128, 48 and 113) (A–B)

128. Transition zone between stipe and blade channelled; blades more or less broadly elliptic or circular, attaining 300 mm in length, superficially smooth unless fertile, then freckled and rough; brownish purple:
Iridaea capensis
(Fig. 129) (A–B)

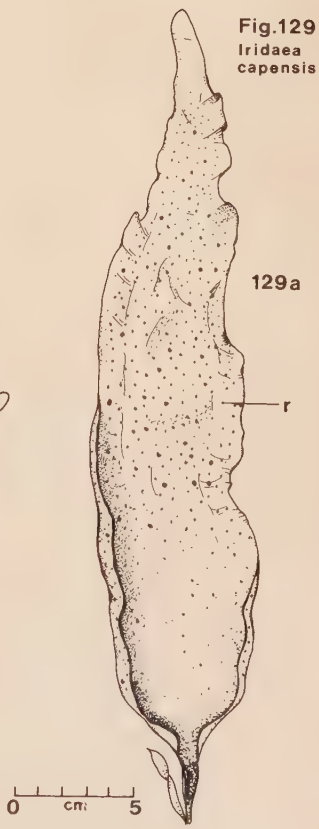
128. Not as above:
129

Fig.126
Gigartina radula

Fig.127
Gigartina paxillata

Fig.128
Gigartina stiriata

Fig.129
Iridaea capensis



129. Margins of blades membranous and crispate; rest of blade thin but fleshy; entirely mucilaginous, flaccid, elongated, lanceolate, simple, not more than 30 mm wide; bluish purple:

Grateloupia longifolia
(Fig. 130) (A–B)

129. Not as above:

130

130. Surfaces reticulately corrugated; primary blade truncated and proliferating terminally into short or substantial blades of elliptic outline; purple:

Phyllymenia belangeri
(Fig. 131) (A)

130. Not as above:

131

131. Blades reticulately corrugated, more or less circular, shortly stipitate, haphazardly perforate; all edges toothed, slightly thickened and often two-lipped; holdfast a callus; purplish red:

Pachymenia cornea
(Figs. 132 and 110) (A–C)

131. Not as above:

132

132. Blades like thick, rubber inner tubing, haphazardly lobed; margins square; stipe flat or cylindrical; blood-red:

Pachymenia carnosa
(Fig. 133) (A–B)

132. Not as above:

133

Fig.130
Grateloupia longifolia

Fig.131
Phyllymenia belangeri

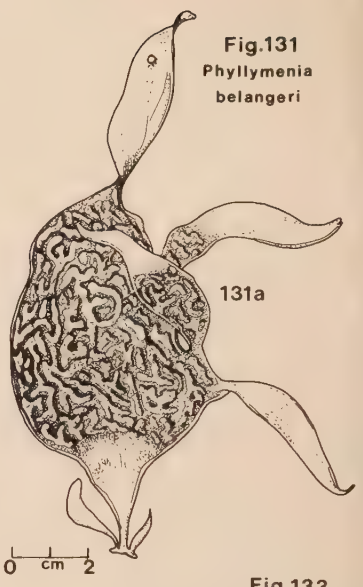


Fig.132
Pachymenia cornea

Fig.133
Pachymenia carnosa

133. Blades fleshy, flaccid, forking haphazardly and unequally; lobes tending to become ragged, more or less elliptic or sometimes truncated and proliferating terminally; margins, when fertile, ornamented with papillae; purplish red:

Sarcodia capensis
(Fig. 134) (B–C)

133. Blades thin but fleshy, lobed haphazardly or somewhat torn, more or less elliptic or obovate, becoming horny on drying; brownish purple:

Schizymenia obovata
(Fig. 135) (A–B)

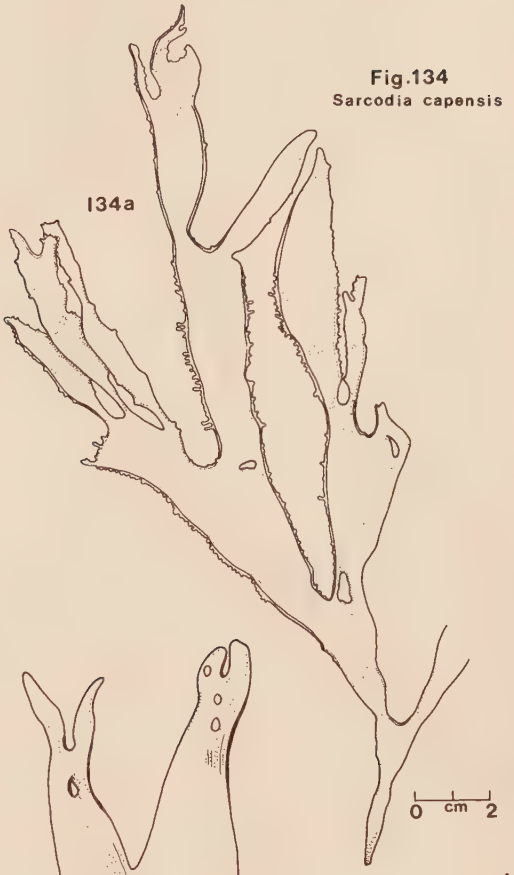


Fig.134
Sarcodia capensis

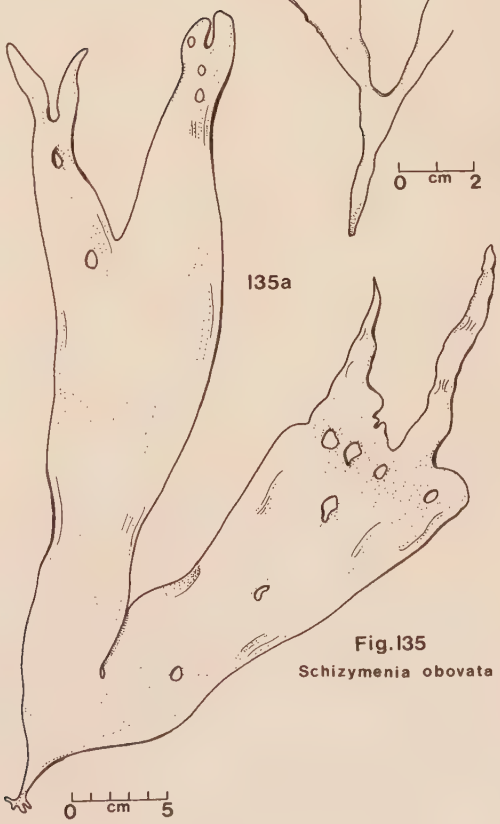


Fig.135
Schizymenia obovata

134. Thallus a rather succulent shrub, shaped like an elaborate candelabra; holdfast conical, robust, horny; axes cylindrical, forking at intervals shortening distally; when fertile, ultimate forks elongated and minutely pitted; brown:

Bifurcariopsis capensis
(Fig. 136) (A–C)

134. Not as above:

135

135. Thallus widely spreading as succulent swards; erect axes cylindrical, not much branched unless fertile, up to 300 mm long; fertile axes compressed, minutely pitted along margins; holdfast of horny narrow runners; brown:

Bifurcaria brassicaeformis
(Fig. 137) (A–B)

135. Not as above:

136

136. Axes deeply and haphazardly constricted; branches perhaps stipitate:

137

136. Axes either without constrictions or constricted only where branches emerge:

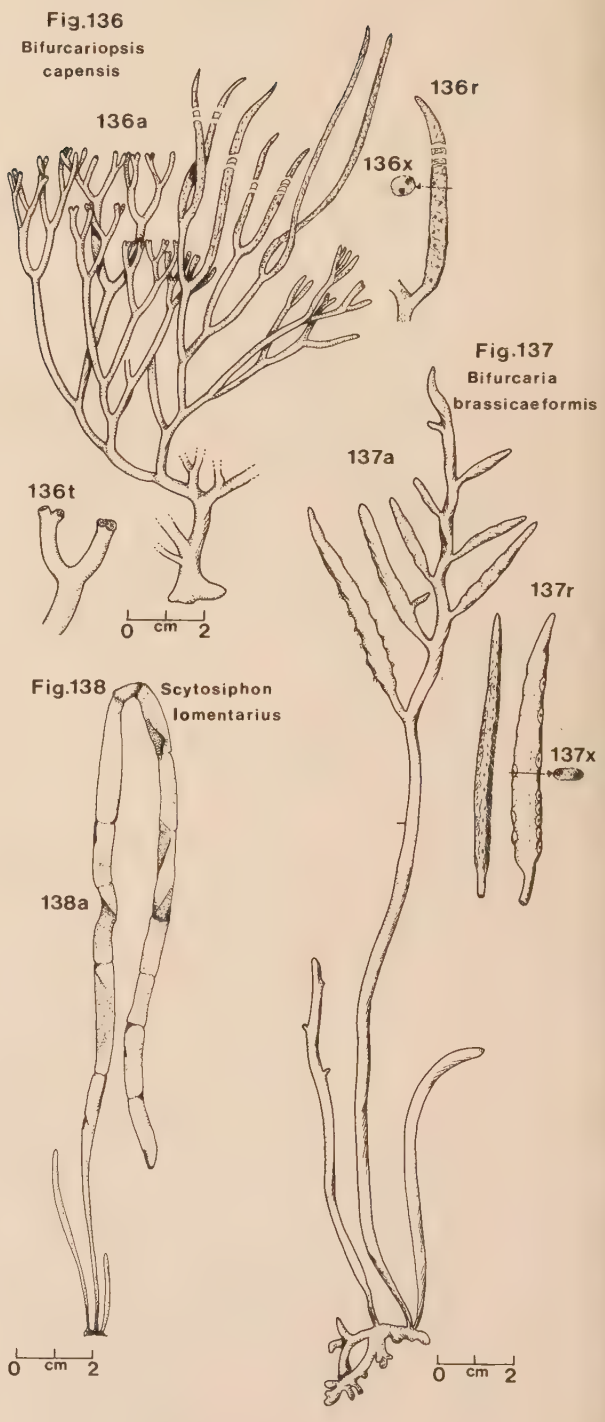
142

137. Thallus a simple, flaccid, hollow tube; greenish brown:

Scytosiphon lomentarius
(Fig. 138) (A–C)

137. Not as above:

138



138. Axes thick, leathery but almost cartilaginous, much compressed; constrictions scattered, but sometimes two may occur in close succession to yield bead-like segments; branching haphazard, but frequently pinnate; branches often stipitate, elongated if sterile, oval if fertile; dark brown:
Axillariella constricta
(Fig. 139) (A–B)

138. Not as above:
139

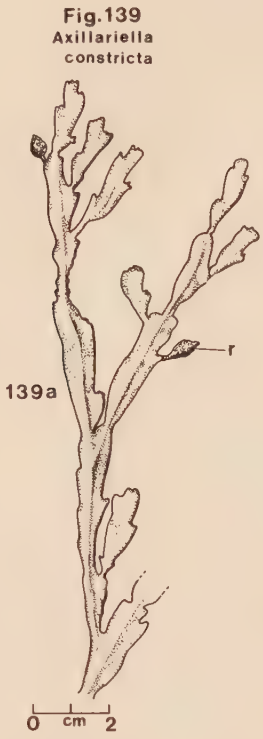
139. Axes horny, scarcely branched, cylindrical, except distally where compressed and distorted; purple:
Prionitis nodifera
(Fig. 140) (D)

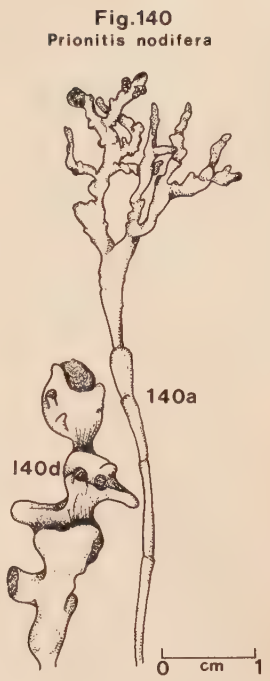
139. Not as above:
140

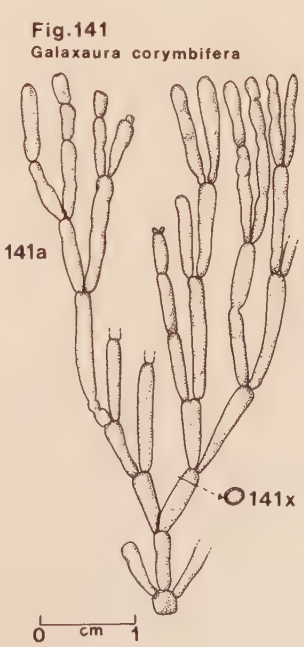
140. Axes pulpy inside a tough pellicle of lime-impregnated material, constricted regularly every 10 mm or so, almost cylindrical, dichotomously forked; mauve:
Galaxaura corymbifera
(Fig. 141) (D)

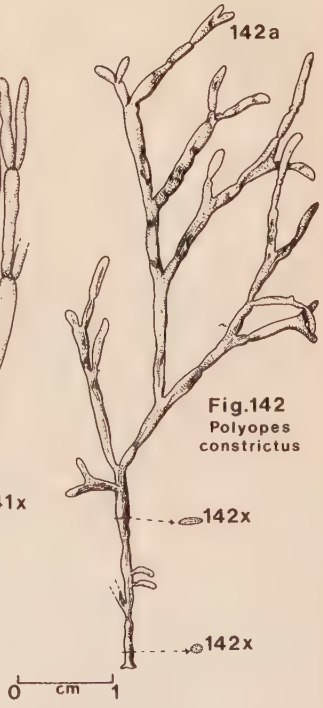
140. Not as above:
141

141. Axes slender and very tough, haphazardly constricted, forking more or less dichotomously in all directions; plant untidy; purple:
Polyopes constrictus
(Fig. 142) (A–B)









141. Axes slender and succulent, beady, branched; branches alternate, opposite or whorled, inserted at joints; a component of intertidal turfs; purple, but often brilliantly iridescent:
Chylocladia capensis
(Fig. 143) (A–B)

142. Axes succulent, translucent, obscurely and regularly segmented (earthworm-like):
143

142. Not as above:
144

143. Axes cylindrical, elongated, erect, branched in unilateral clusters at irregular intervals; purplish red:
Champia lumbricalis
(Fig. 144) (A–C)

143. Axes much compressed, short, bilaterally and most often oppositely branched, almost creeping; brownish purple, but iridescent:
Champia compressa
(Fig. 145) (A–C)

144. All free axes pinnately branched; branches inserted almost in one plane:
145

144. Not as above:
154

145. Thallus almost horny, strongly compressed; ultimate pinnae subspherically swollen and apically depressed; depression contains a pit filled with microscopic hairs; purple:
Laurencia complanata
(Fig. 146) (D)

145. Not as above:
146

Fig. 143
Chylocladia capensis

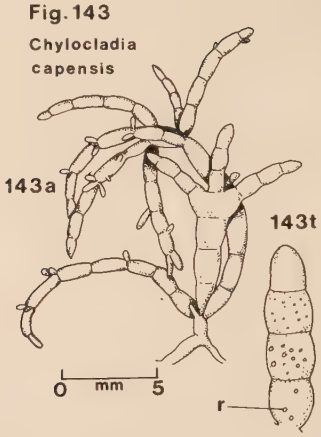


Fig. 145
Champia compressa

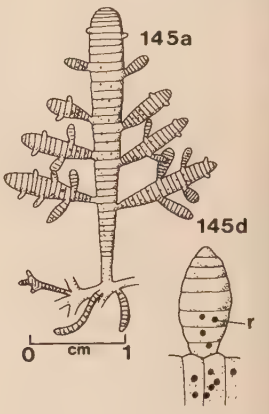


Fig. 144
Champia lumbricalis

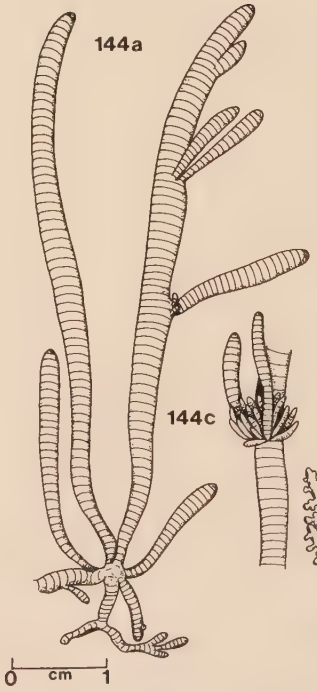
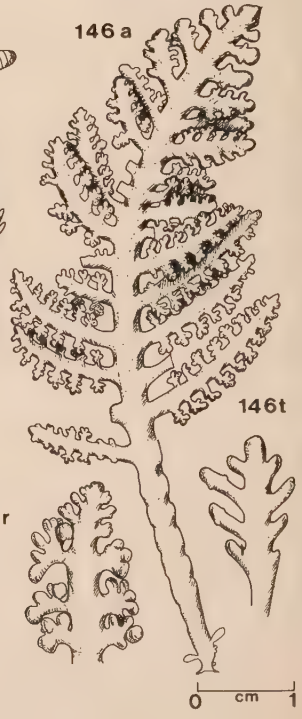


Fig. 146
Laurencia complanata



146. Pinnae bilateral in alternate, secund series of twos or threes; lowest of pinnae in each series simple; other pinnae compound; purplish red or brown:

147

(*Plocamium* spp.)

146. Not as above:

149

147. Pinnae in secund series of not more than two, somewhat crowded, overlapping distally; brownish:

Plocamium cornutum
(Fig. 147) (A–C)

147. Pinnae in secund series of mostly three in distal parts:

148

148. Pinnae in secund series of three in all parts:

Plocamium beckeri
(Fig. 148) (B–E)

148. Pinnae in secund series of two proximally:

Plocamium rigidum
(Fig. 149) (A–C)

149. Slender and wiry, haphazardly and lightly notched, resembling a coarse asparagus-fern; blackish purple; holdfast of slender purplish runners:

150

149. Not as above:

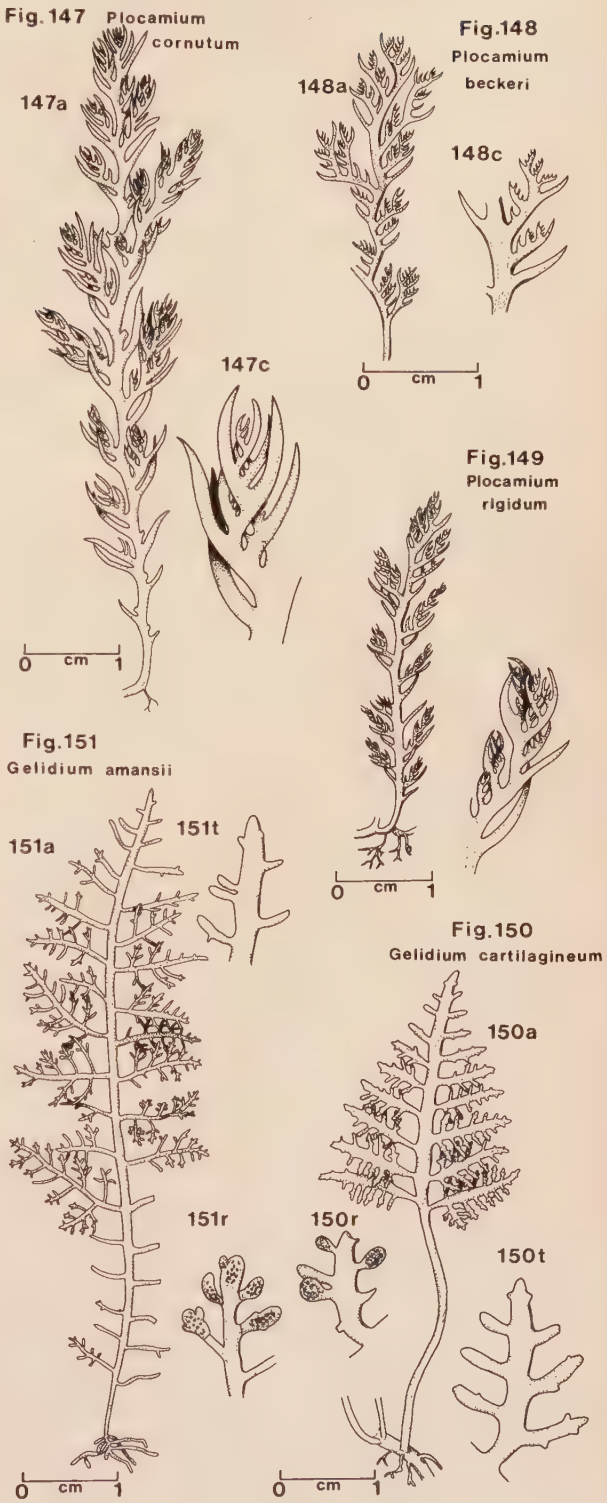
151

150. Ultimate pinnules compressed, when fertile, pointed and subapically swollen; frond neatly bilateral:

Gelidium cartilagineum
(Fig. 150) (A–D)

150. Ultimate pinnules cylindrical, if fertile slightly swollen apically; frond untidily bilateral:

Gelidium amansii
(Fig. 151) (B–D)



151. Thallus thin but fleshy and very flaccid, compressed:
152

151. Not as above:
153

152. Epiphytic on *Ecklonia maxima* (Fig. 54); main axis elongated, much branched and frilled with minute leaflets; purple:
Carpoblepharis flaccida
(Figs. 152 and 103) (A–B)

152. Not epiphytic; main axis not obvious, much branched; branches of variable length; brownish purple:
Grateloupia filicina
(Figs. 153 and 102) (A–B)

153. Fronds minutely but coarsely and sometimes brokenly pinnate, opaque except ultimately where obscurely translucent; translucent parts reticulately segmented; blackish:
Pterosiphonia cloiophylla
(Fig. 154) (A–B)

153. Fronds neatly and repeatedly pinnate to look like a delicate asparagus-fern; epiphytic on a variety of larger seaweeds; purple:
Ceramium planum – complex
(Fig. 155) (A)

Fig.152
Carpoblepharis
flaccida

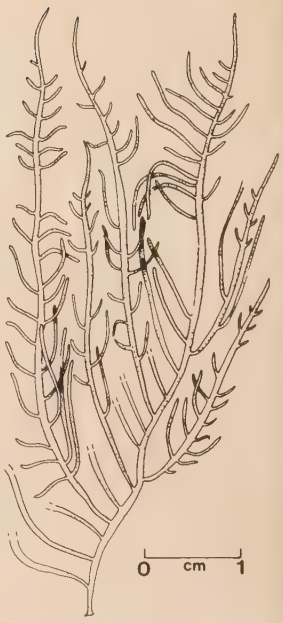


Fig.153
Grateloupia
filicina

Fig.154
Pterosiphonia
cloiophylla

Fig.155
Ceramium planum-complex

154. Thallus a small spiky pile up to 25 mm high and 100 mm wide; brownish purple:
Caulacanthus ustulatus
(Fig. 156) (A–D)

154. Not as above:
155

155. Axes terete, slender but fleshy, tapering to a delicate point; purple, perhaps shot with green:
156

155. Not as above:
158

156. Axes in a loose tangle:
Hypnea rosea
(Fig. 157) (D–E)

156. Not as above:
157

157. Axes not much longer than 350 mm; few main branches; short spiky branches numerous and crowded more or less unilaterally subapically; holdfast of slender runners:
Hypnea spicifera
(Figs. 158 and 45) (A–E)

157. Axes very long, stringy, profusely branched; thalli secondarily attached in sand under lagoon conditions; reddish purple:
Gracilaria verrucosa
(Fig. 159) (Saldanha B. and Swartkops R. Estuary)

Fig.156
Caulacanthus ustulatus

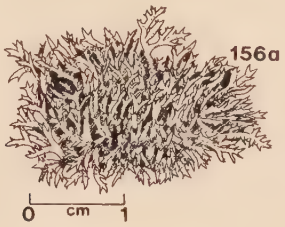


Fig.157
Hypnea rosea

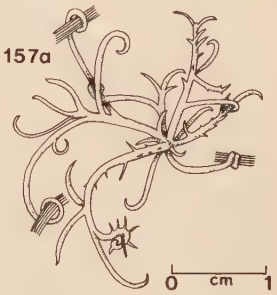


Fig.158
Hypnea spicifera

Fig.159
Gracilaria verrucosa

158. Thallus a heath-like shrub:
159

158. Not as above:
160

159. Holdfast a woody cone supporting a single, short, robust stipe; primary stipe soon divides repeatedly into many lesser branches; branches more or less erect; leaflets spiny, quadrifarious on each axis; purple:

Spyridia cupressina
(Fig. 160) (C–D)

159. Holdfast diffuse, producing several elongated main axes; main axes bearing many branched laterals; leaflets in a tight spiral on each axis; purple:

Spyridia hypnoides
(Fig. 161) (D)

Fig. 160
Spyridia cupressina

Fig. 161
Spyridia hypnoides

160. All appendages berry-like; purplish red:
Botryocladia madagascariensis
(Fig. 162) (C–D)

160. Not as above:
161

161. Plant flaccidly erect, stringy with abundant laterals inserted at right-angles on the parent axes; one or a few primary axes; light brown:
Chordariopsis capensis
(Fig. 163) (A–B)

161. Not as above:
162

162. Almost entirely succulent:
163

162. Not entirely succulent:
173

163. Main axis sparingly branched; all axes carry single whorls of thorny appendages at discrete intervals; purple:
Gracilaria aculeata
(Fig. 164) (C–D)

163. Not as above:
164

164. Most branching dichotomous; fertile plants covered with warty blisters, especially in the distal parts:
165

164. Not as above:
169

165. All branching dichotomous:
166

165. Not as above:
168

166. Ultimate axes slightly contorted and ribbed; brownish purple:
Gymnogongrus complicatus
(Fig. 165) (A–B)

166. Not as above:
167

Fig.163
Chordariopsis capensis

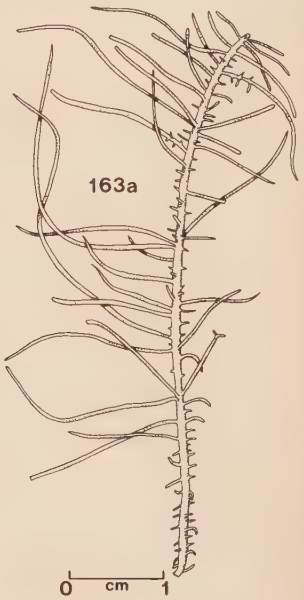


Fig.162
Botryocladia
madagascariensis

Fig.165
Gymnogongrus complicatus

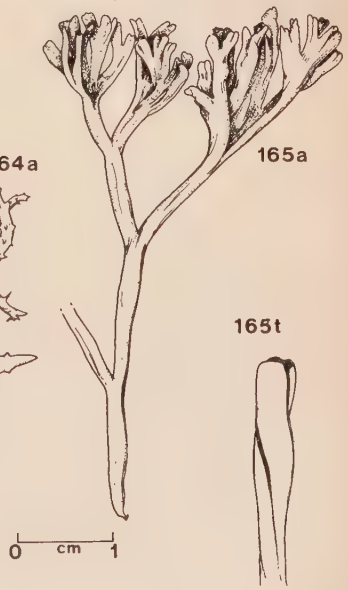
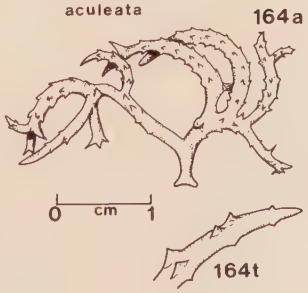


Fig.164
Gracilaria
aculeata

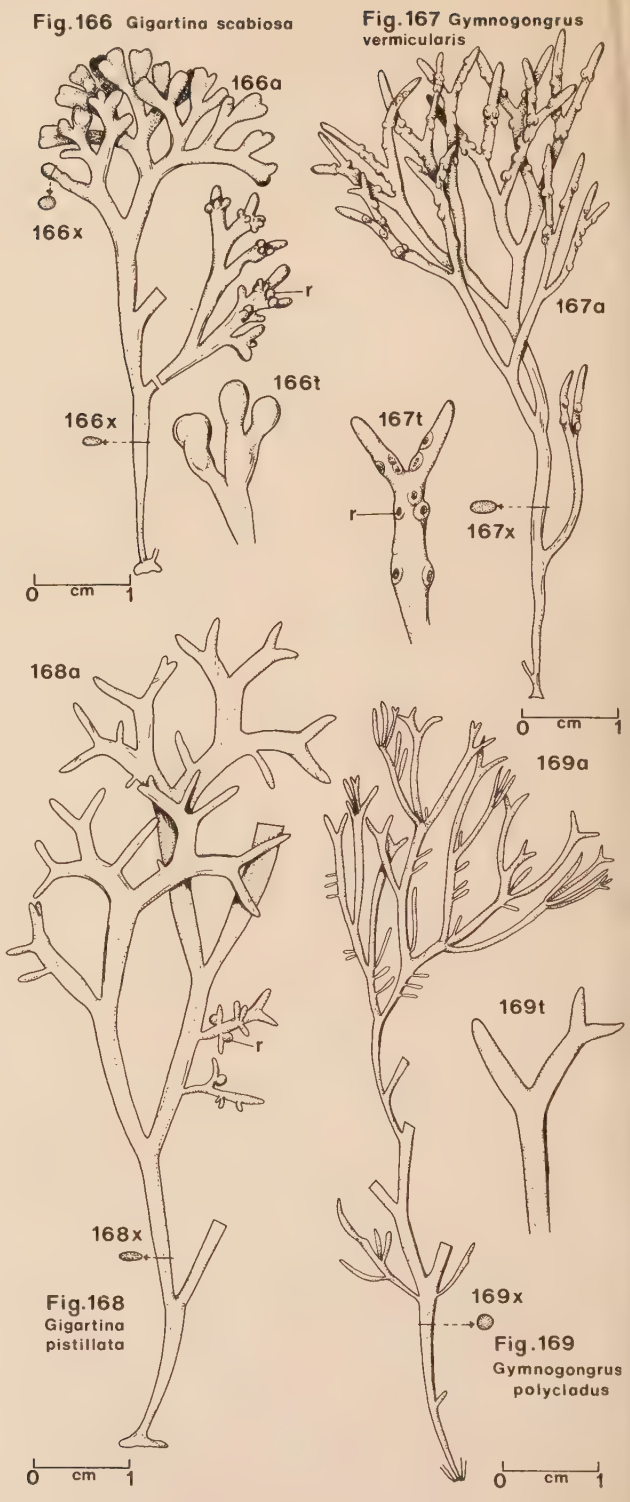


167. Ultimate axes slightly swollen and apically indented; all axes compressed, dichotomizing at short intervals; plants making dense stands up to 60 mm high; purple:
Gigartina scabiosa
(Fig. 166) (A–B)

167. Ultimate axes tapering very slightly to blunt ends; axes lightly compressed, dichotomizing a few times; plants more or less isolated, up to 150 mm high; brownish purple:
Gymnogongrus vermicularis
(Fig. 167) (A–C)

168. Axes more or less twiggy with many short laterals standing off at right-angles, for the most part compressed; purple:
Gigartina pistillata
(Fig. 168) (B–C)

168. Axes more or less twiggy with laterals standing off at about 45°, sometimes truncated and proliferous at the exposed edge, for the most part cylindrical; purple:
Gymnogongrus polycladus
(Fig. 169) (B–C)



169. Axes much compressed; branching bilateral or in all directions:
170

169. Axes more or less cylindrical; branching in all directions:
171

170. Axes not rising higher than 50 mm; not much branched; branched in all directions; branches often stubby; greenish purple:
Laurencia pumila
(Fig. 170) (D)

170. Axes rising higher than 50 mm; branched bilaterally, often but discretely; purple:
Laurencia flexuosa
(Fig. 171) (C–D)

171. Axes not rising higher than 50 mm; branches somewhat crowded; tips discoloured to reddish; greenish purple:
Laurencia natalensis
(Fig. 172) (D)

171. Axes rising higher than 50 mm; tips of axes not discoloured:
172

172. Branchlets densely crowded in a conical fashion on the parent axes; purplish brown:
Laurencia glomerata
(Fig. 173) (A–D)

Fig. 170
Laurencia pumila

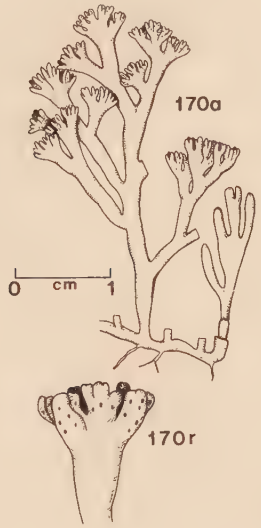


Fig. 171
Laurencia flexuosa

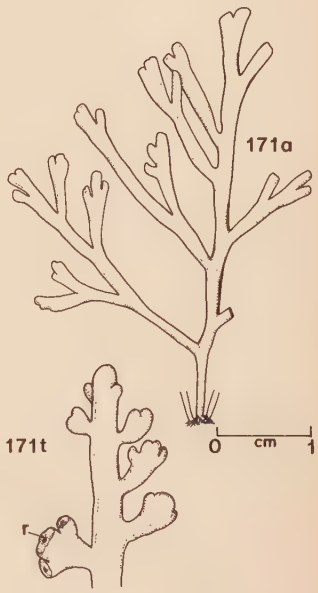


Fig. 172
Laurencia natalensis

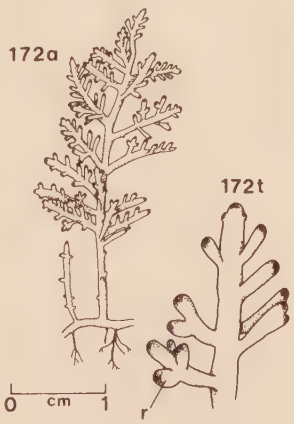


Fig. 173
Laurencia glomerata

172. Branches well spaced; axes for the most part tapering upwards to a gelatinous, irregular apex ornamented with submacroscopic hairs and downwards to a narrowed base; purple:

Chondria capensis
(Fig. 174) (A–B)

173. Axes slender, tough:

174

173. Axes filamentous:

176

174. Bristly feather-like appendages present; brown to blackish:

Phloiocaulon squamulosum
(Fig. 175) (D)

174. Not as above; axes purple with tips discoloured reddish:

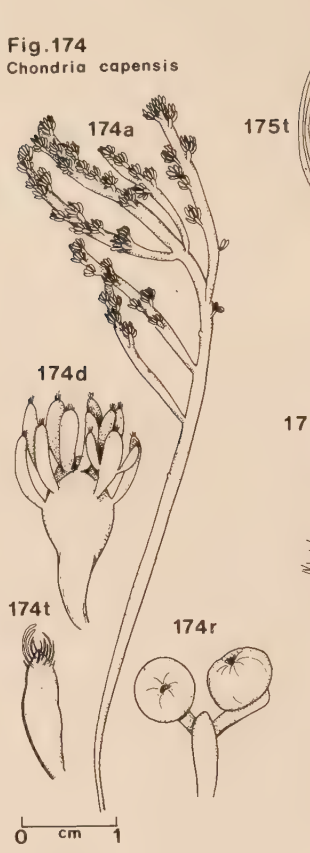
175

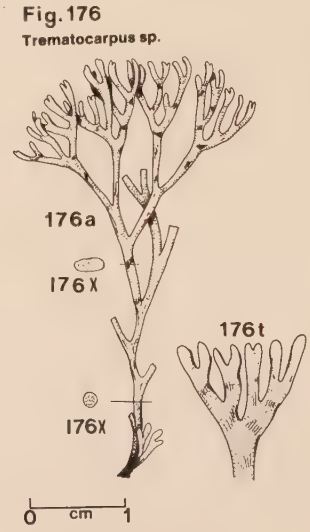
175. Axes terete proximally, compressed almost to flat distally, dichotomizing laxly but at progressively closer intervals and almost in one plane; plants together forming dense stands up to 200 mm high·

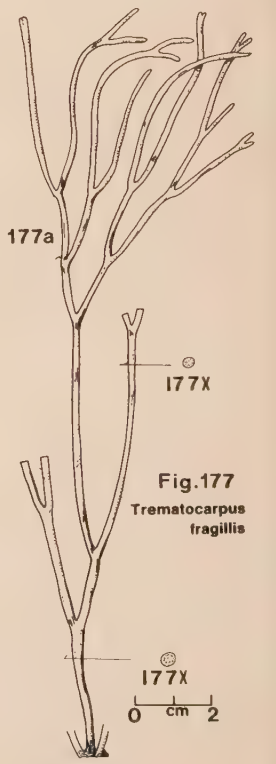
Trematocarpus sp.
(Fig. 176) (A–C)

175. Axes more or less entirely terete, dichotomizing at progressively closer intervals but remaining well spaced, clustering but not crowded; plants up to 300 mm high:

Trematocarpus fragilis
(Fig. 177) (A–B)







176. Besom-like tufts of filaments compounded together below, free apically; dark brown:
Halopteris funicularis
(Fig. 178) (A–B)

176. Not as above:
177

177. Ultimate branchlets submacroscopically uniseriate, pigmented; plant like a bottle-brush in shape:
Aristothamnion spp.
e.g. *A. collabens*
(Fig. 180) (A)
Dasya spp.
(Fig. 181) (A–D)
Pleonosporium spp.
(A–D)
178
(*Callithamnion* spp.)

177. Ultimate branchlets, if submacroscopically uniseriate then unpigmented, otherwise not as above:
179

178. Thallus like fine, twisted yarn, ultimately unravelled; purple:
Callithamnion stuposum

178. Reproductive structures formed in one of two ways, firstly as submacroscopic, naked balls of microscopic spores loosely clasped by digit-like filaments at the ends of elongating branches, and secondly as submacroscopic spheres containing a tetrahedron of spores and carried laterally on short branchlets; purple:
Callithamnion spp.
(Fig. 179) (A–E)

Fig.178
Halopteris funicularis

Fig.179
Callithamnion spp.

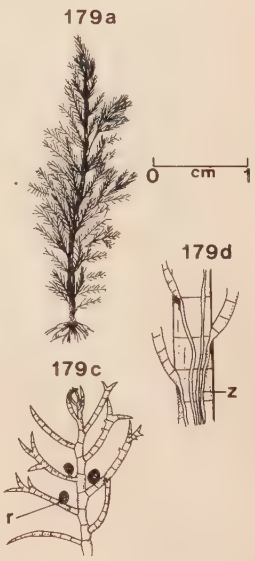
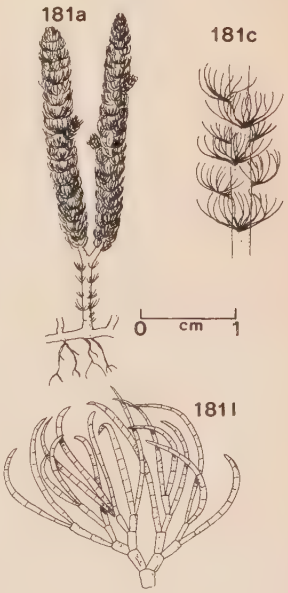


Fig.180
Aristothamnion collabens

Fig.181
Dasya sp.



179. Thallus whip-like with elongated branches arising in a lax spiral; terminal submacroscopic or even microscopic forked hairs commonly occur; axes patently or obscurely segmented, with or without a covering reticulum of microscopic cortical cells; primary segments vertically divided into central and pericental columns; spores buried in the tissue and causing local swelling or contained in submacroscopic, urn-shaped or spherical appendages; purple:

180

(*Polysiphonia* spp. and related taxa)

179. Not as above:

181

180. Microscopic cortical cells, if present, only on outside of pericentrals:

Polysiphonia spp.
e.g. *P. urbana*
(Fig. 182) (A–E)

180. Microscopic cortical cells on outside and inside of the pericentrals; plant epiphytic on *Ecklonia maxima* (see Fig. 54):

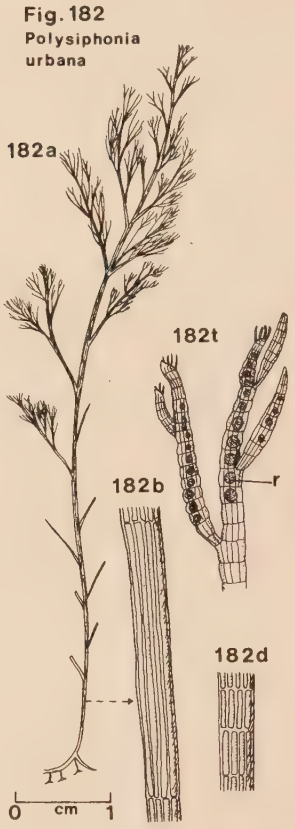
Carradoria virgata
(Fig. 183) (A–B)

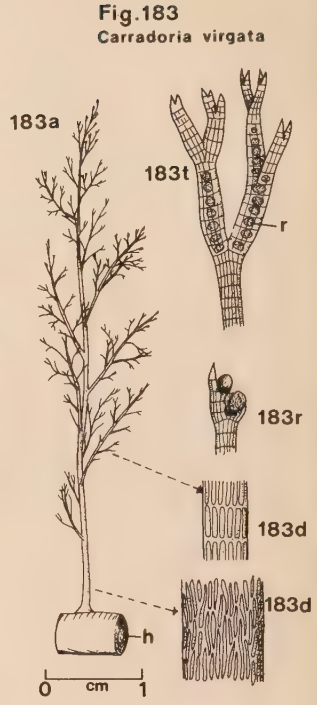
181. Most branches short, awl-shaped, arising in a spiral; submacroscopic primary segments vertically divided into central and several pericentral cells; reproductive structures like those of *Polysiphonia* spp. (see par. 179); blackish:

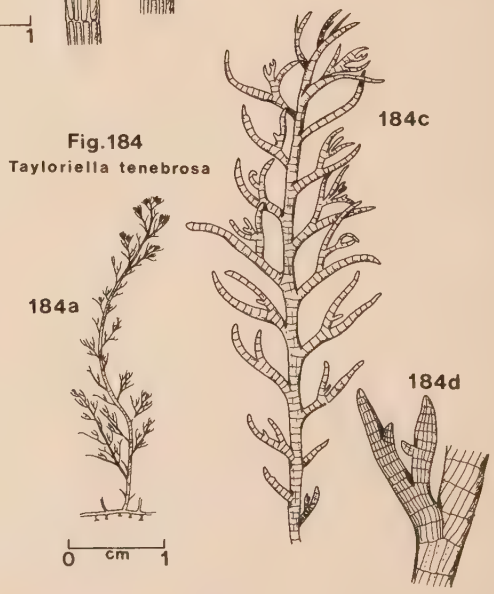
Tayloriella tenebrosa
(Fig. 184) (A–C)

181. All axes uniseriate filaments, partially or completely covered with microscopic cortical cells, terminated by incurving claw-like portions, terminally or entirely translucent; reproductive structures naked and exposed like those of *Callithamnion* spp. (see par. 178) or buried in the tissues like some in *Polysiphonia* spp. (see par. 179); purplish red:

182







182. Thallus whip-like, branching in all directions; branches often in a whorl at each node; axes mostly opaque and slightly beaded; epiphytic on a variety of larger seaweeds; purple:
Ceramium capense (Fig. 185) (A–B)

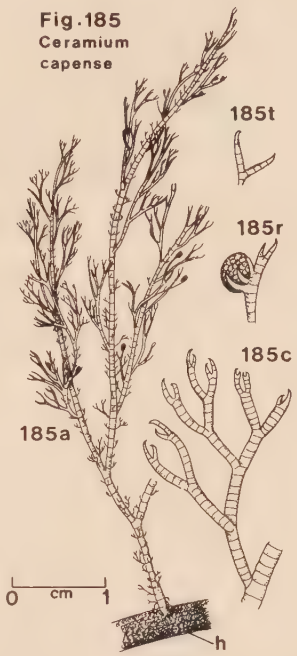
182. Not as above:
183

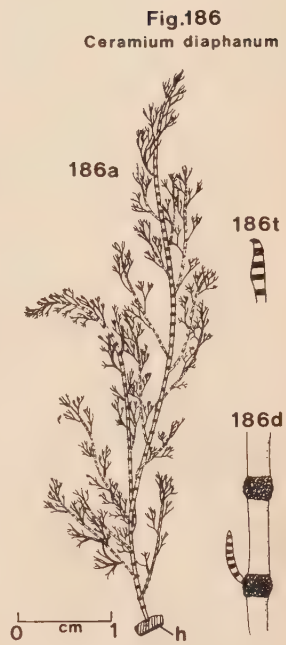
183. Cortex interrupted, forming blackish girdles on otherwise colourless filament; plants small and epiphytic:
Ceramium diaphanum-group (Fig. 186) (A–E)
Ceramium glanduliferum (C–D)
Ceramium arenarium (A–C)
Ceramium tenerrimum (A–C)
Ceramium papenfussianum (A–D)

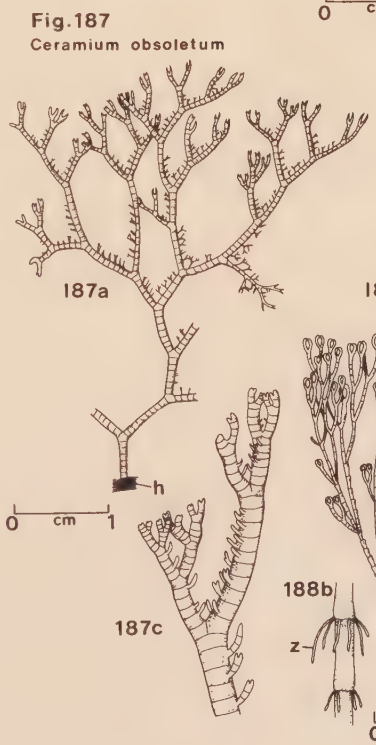
183. Cortex continuous except perhaps at the tips of the axes:
184

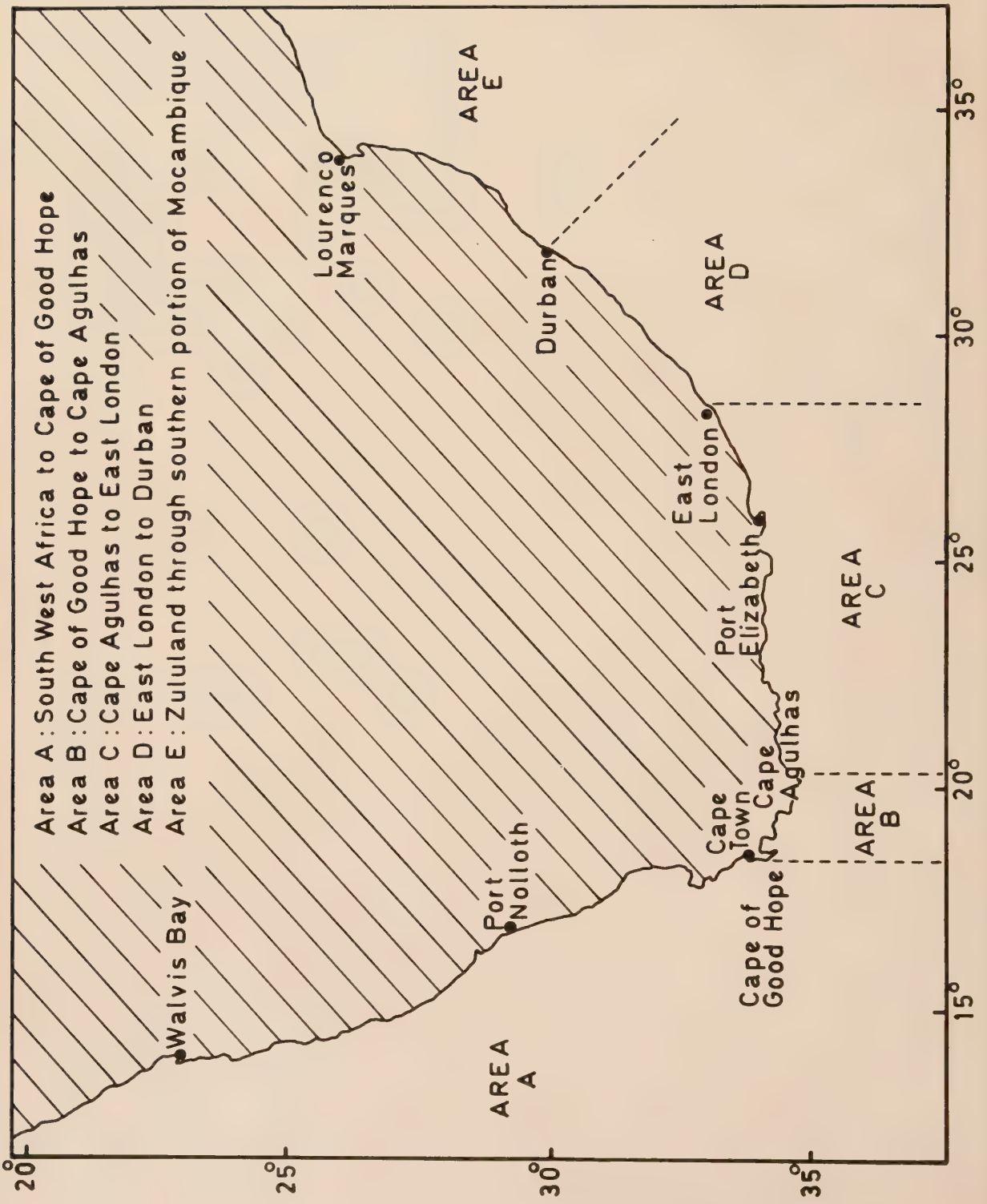
184. Plant relatively large, up to 200 mm high; main branching dichotomous at discrete intervals which become shorter distally; minor branches form a frill on inner surfaces of major branches; all branches diverge at right-angles; epiphytic; purple:
Ceramium obsoletum (Fig. 187) (A–B)

184. Axes less than 100 mm long, flaccid, forming isolated tangles or more extensive swathes of black "hair" in shallow, damp depressions or pools in the mid to lower littoral levels; cortical cells formed in rows and columns; nodes often marked by a single ring of submacroscopic spines:
Centroceras clavulatum (Fig. 188) (A–D)








Area A : South West Africa to Cape of Good Hope
Area B : Cape of Good Hope to Cape Agulhas
Area C : Cape Agulhas to East London
Area D : East London to Durban
Area E : Zululand through southern portion of Mocambique
Walvis Bay
Port Nolloth
Cape of Good Hope
Cape Town
Cape Agulhas
Port Elizabeth
East London
Durban
Lourenco Marques
AREA A
AREA B
AREA C
AREA D
AREA E
20°
25°
30°
35°
15°
20°
25°
30°
35°

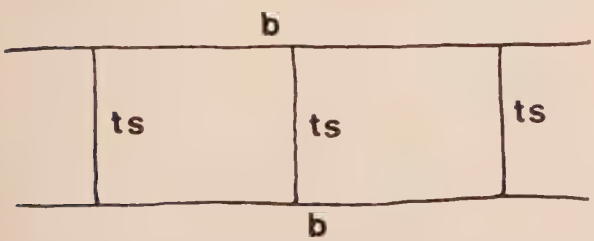
STRUCTURE AND DEVELOPMENT

An entire seaweed may look like a single, simple dicotyledonous leaf whereas another may seem to be organized into roots, stems and leaves. Among highly organized species is the massive Brown Alga, *Ecklonia maxima* (Fig. 54), so abundant on the shores of the Cape Peninsula and elsewhere along the West Coast. Simpler shapes which mature seaweeds may have include a variety of crusts coating rock or other substrata, gelatinous or spongy fibrous balls and amorphous blobs. Somewhat more complex than the last are the many branching filaments or stem-like thalli consisting of large numbers of uniformly cylindrical or flattened axes.

Whatever its ultimate appearance, the thallus (plant-body) of an Alga does not possess structures homologous with the roots, leaves and stems of flowering-plants; such organs as they may have are termed holdfasts (root-like), stipes (stem-like) and fronds (leaf-like). These thallic organs, like the rest of the plant, grow as a result of cell division. The activity of cell division has either no specific location (diffuse growth) or it is concentrated in a specific meristem (see below).

The filament as structural unit

Seaweeds most often begin their thalloid lives as a microscopic primordial thread or filament which may be negatively or positively geotropic; negative geotropism results in erect-growing filaments whereas positive geotropism yields prostrate filaments. During its development from a uninucleate disseminator (spore), the single nucleus of the developing filament undergoes nuclear division, and each time a nucleus divides a septum may be formed to separate the two daughter nuclei. If such septation occurs only transversely across the filament, a ladder-like body results, and, because the segments form a single column, the filament is described as uniseriate.



Portion of a longtitudinal section through a uniseriate filament
b: outer surface; ts: transverse septum

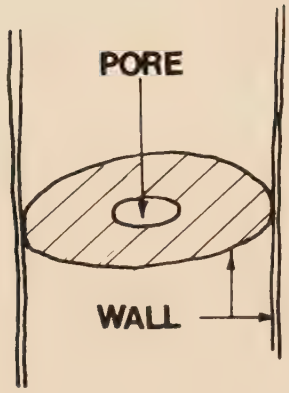
A uniseriate filament formed as described above consists of a single series of uninucleate cells. A uniseriate filament may, however, contain a series of multinucleate segments as are to be found, for example, among Cladophorales (Chlorophyta). Such multinucleate segments are called coenocytes.

Coenocytic habit – The coenocytic condition, in which such segments as may exist contain several nuclei, is of frequent occurrence among a variety of seaweeds but it is a consistent and remarkable vegetative characteristic of two Orders of Green Algae – the Cladophorales, already mentioned above, and the Siphonales; it features occasionally in some Red algal Genera such as *Callithamnion* species (Fig. 179) and *Griffithsia* species; it does not, however, occur in Brown Algae. The Cladophorales are segmented but many of the Siphonales lack any form of vegetative septation (aseptate) of their individual filaments. Generally speaking, coenocytic segments are large and, if not visible to the naked eye, may be discerned under relatively low magnifications. It is difficult to appreciate that an aseptate filament can attain the dimensions, toughness and morphological complexity that thalli of *Caulerpa filiformis* (Fig. 10) have. The strength necessary to maintain the form of such a *Caulerpa* is derived from the presence of a complex mesh of cellulose ribs formed within the otherwise hollow structure.

Like the cellulose meshwork in *Caulerpa filiformis* the series of transverse septa in the Cladophorales strengthens an otherwise hollow structure because, in spite of appearances, these septa are not formed in the way typical of those of the Ulotrichales or of the Phaeophyta.

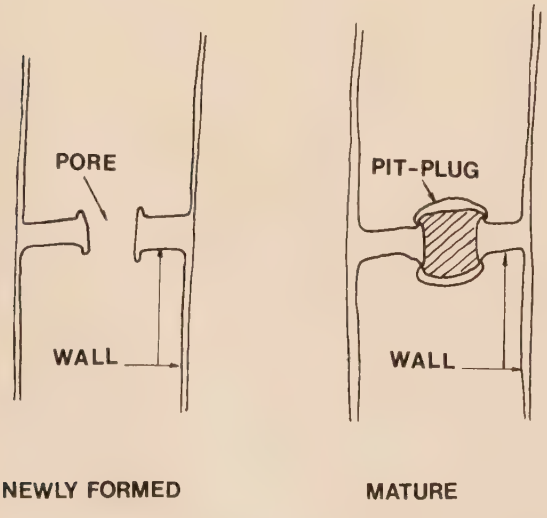
This statement raises the matter of septum-formation which has four different manifestations in Algae.

Septation – Septation in Cladophorales (Chlorophyta), for example *Chaetomorpha robusta* (Fig. 15), is peculiar in that it occurs independently of nuclear division, although it is almost certainly genetically controlled. A segment anywhere along the length, but usually the apical one itself, of a filament of such a plant initiates a septum by building up a peripheral ring of inner wall material. This ring lying in the transverse plane materializes centripetally to form the septum.



Cladophora sp.: oblique optical section of a portion of filament to show developing septum

Septa in members of the Class Florideophyceae (Rhodophyta), too, have a peripheral origin but are otherwise differently constituted. A difference arises in that the florideophycean septum, called a pit-connection (represented by two bars in the diagram), does not close but forms an annulus, the pore of which sooner or later becomes plugged by material distinct from the normal wall-material. A further difference is that the florideophycean septum forms during mitosis and materializes between the products of a dividing nucleus in the way usual to parenchymatous tissues.



A longitudinal section through a pit connection of a Red Alga filament

Members of the Ulotrichales (Chlorophyta), of all Brown Algae and of Bangiophyceae (Rhodophyta) form septa in the parenchymatous way characteristic of all higher plants. In these cases, a cell is usually uninucleate. During metaphase of somatic cell-division (mitosis) a membrane materializes in the median plane of the centrally placed dividing nucleus. This membrane rapidly builds up, centrifugally, to the peripheral wall of the mother cell and wall-material is deposited on either side of it; a completed median membrane, formed as described but without its wall material, constitutes a middle lamella and is typical of parenchymatous tissues.

The fourth type of septation, entirely different from anything so far described, occurs in some members of Fritsch's Siphonales (Chlorophyta). This process is "segregative division" and it occurs in the balloon-like compound vesicles constituting plants such as *Valonia macrophysa* (Fig. 8) or *Dictyosphaeria* (not illustrated). Multinucleate portions within the primary coenocytic segments or vesicles of these plants become spontaneously and separately surrounded by wall material. Such secondary vesicles may or may not fill the primary structure. In *Valonia* species, for instance, the few secondary vesicles formed, occupying relatively little of the available space, migrate to the apex of the parent vesicle and, after a short lapse of time, each balloons upwards and outwards more or less simultaneously to create branch-like members conforming in appearance with the parent. Wall-material of a secondary vesicle fuses with that of another secondary vesicle or of the parent vesicle with which it makes contact.

Thallus-formation

Any multicellular plant body of the non-vascular type constitutes a thallus. In its mature form a thallus may be very simple as in *Chaetomorpha* species (Figs. 14–17) or it may be very complex as in *Ecklonia maxima* (Fig. 54). In the event, genetic heritage determines developmental patterns leading from the single-celled propagating cell to the multicelled state. A parenchymatous type of development initiated and continued by cell-division in a more or less apical meristematic tissue, as is characteristic of flowering-plants, is a property possessed by some Algae but not all. The simplest algal thallus is the unbranched uniseriate filament already referred to. Such a filament represents the lowest evolution of the monosiphonous thallus.

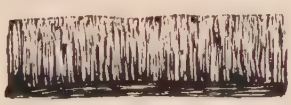
Monosiphonous habit – The monosiphonous habit is displayed, not only in the simple uniseriate filaments possessed by *Chaetomorpha* species, but also by simple aseptate forms and by branched uniseriate or aseptate thalli. Typical branched forms are illustrated by *Cladophora* species (Figs. 18–23) and *Bryopsis* species (Figs. 24, 26 and 27) among Chlorophyta, by *Ectocarpus* species (not illustrated) in the Brown Algae and by *Griffithsia* species (not illustrated) in Rhodophyta.

Monosiphonous filaments may, however, form parts of more complex structures which may include a variety of corticated types or, very frequently, the heterotrichous habit.

Heterotrichous habit – The plants having the monosiphonous habit mentioned above consist for the most part of negatively geonastic filaments which, therefore, tend to grow erect. The primordial filaments of these, or other plants, may be positively geonastic and therefore adherent to the hard surfaces on which they grow. This prostrate filament may become more or less complex and, in addition, develop from its dorsal surface (surface furthest from the substratum) negatively geonastic filaments. This habit, consisting of two portions, namely prostrate and erect systems, constitutes heterotrichy. It is probably basic to most seaweeds, but the prostrate system is usually completely masked in maturity.

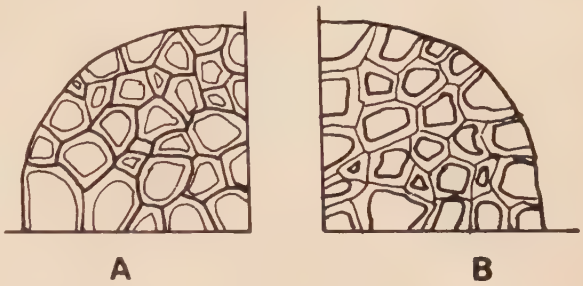
The heterotrichous habit

A warning should be sounded here, because some seaweeds, such as laterally spreading skins like *Ralfsia expansa* (Fig. 67), or calcareous crusts like the encrusting corallines (Fig. 65), appear to consist entirely of a prostrate system. Such skins and crusts, however, usually consist mainly of coalescent, erect filaments of the erect system of the heterotrichous habit.



Structure of an encrusting coralline Alga to show that its greatest bulk consists of the erect filaments

Pseudoparenchyma – The foregoing statement about coalescent filaments raises a matter which for algal structures has very great importance. Coalescence of the sort mentioned and congenital fusions of daughter with parent filaments occur in a very large number of seaweed species, and resulting tissues have the anatomical appearance of true parenchyma. Because of this resemblance the fasciated tissues referred to are called pseudoparenchyma. (It should be remembered that true parenchyma is derived by successive septations of a single primary cell.)

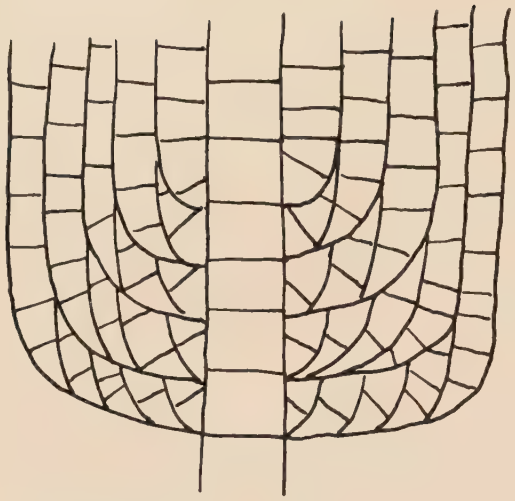


Transverse sections
A: portion of a segment of pseudoparenchyma; B: portion of a segment of thick-walled parenchyma

All members of the Class Florideophyceae (Rhodophyta), when not monosiphonous, are pseudoparenchymatous. Many members of both Greens and Browns are either entirely or partly pseudoparenchymatous.

Pseudoparenchymatous thalli can become as strong or tough as almost any annual flowering-plant and may exhibit a fair degree of tissue-differentiation. But whatever mature form they may have they originate from either one or several uniseriate filaments constituting a skeletal core. Where a single primary filament is involved the habit is termed uniaxial, otherwise the condition is multiaxial. Gross morphology of species of seaweeds need not express which of the two origins are involved.

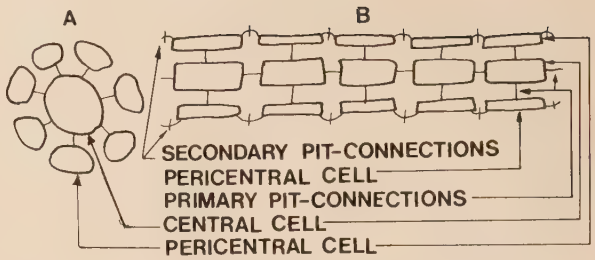
The shapes and sizes of mature thalli are functions of the dispositions and dimensions of the component filaments. Thus, *Desmarestia firma, Splachnidium rugosum* (Fig. 52), *Hypnea spicifera* (Figs. 45 and 158), *Martensia elegans* (Fig. 63), *Botryocarpa prolifera* (Fig. 123) and *Polysiphonia* spp. (e.g. Fig. 182) are all of the uniaxial type but represent a range of thalloid forms determined by variations in branching habit of the fused members. During development of the foliaceous types mentioned above, distinct cell-rows



Pseudoparenchyma: plan of uniaxial construction as in *Desmarestia*

representing individual uniseriate filaments may be visible under the microscope if the tissue of the thallus being examined is sufficiently thin to allow light to pass. In such a way it is possible to trace in *Acrosorium uncinatum* (Fig. 105) many of the cell-rows representing individual uniseriate filaments and their branches because they are disposed in a single plane.

Uncorticated *Polysiphonia* species (e.g. Fig. 182) illustrate a particular kind of uniaxial structure named polysiphony. Polysiphony, literally meaning many-tubed, results from a segmentation pattern in which every cell of a uniseriate filament segments longitudinally, repeatedly and asymmetrically. The effective configuration is thus of central-column cells each ringed by a number of equally long pericentral cells. Subsequently, pericentral cells of adjacent segments become linked secondarily in a manner affecting a primary pit-connection, thus leading to the "polysiphonous" condition. The number of pericentral cells in successive segments is more or less constant and specific for a species; the least number is three. This polysiphonous structure is basic to all members of the Families Rhodomelaceae, Dasyaceae and Delesseriaceae, which together belong in the Order Ceramiales (Florideophyceae, Rhodophyta). Lateral or radial extension of this basic polysiphonous column results in morphologies as different from one another as *Polyzonia elegans* (Fig. 94) and *Laurencia glomerata* (Fig. 173), or *Martensia elegans* (Fig. 63) and *Dictymenia stephensonii* (Fig. 96).



Polysiphonous construction
A: transverse section; B: longitudinal section

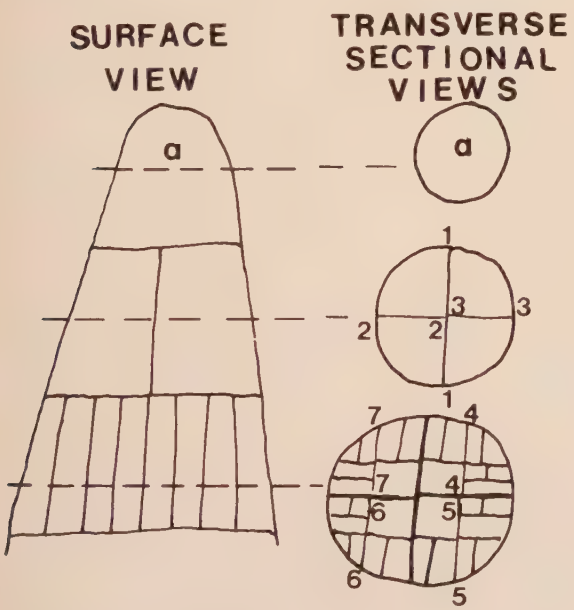
By contrast with the single primary filament of the uniaxial construction, a multiaxial thallus basically consists of a number of adjoined primary uniseriate filaments. Thus, skin- and crust-like thalli may more than likely be multiaxial and not consist only of the prostrate system. Examples of this multiaxial form are *Hildenbrandia pachythallos* (Fig. 68), *Ralfsia expansa* (Fig. 67) and *Lithothamnion* species (Fig. 65). But, multiaxial thalli are not represented only by laterally spreading forms with limited upward extension. They may, like *Rhodymenia natalensis* (Fig. 117), *Epymenia obtusa* (Fig. 116), *Champia lumbricalis* (Fig. 144) and *Gymnogongrus vermicularis* (Fig. 167) be outwardly no different in appearance from uniaxial forms or from the parenchymatous types which will be discussed. To form such multiaxial plant-bodies as are represented in the four species last mentioned requires that only a certain number of primary erect filaments participate in the development of each axis. It must be obvious that this involves a high degree of organization. The fact that stress is laid above on the participation of primary filaments in the multiaxial structure is not intended to mean exclusiveness (secondary and higher order filaments can and do participate) but merely to point out the basic requirement for the multiaxial type. It must be mentioned too, that a multiaxial type of axis may consist of meshing filaments, which do not actually become coalescent, as in *Codium* species (Figs. 29–44).

Cortex – Uncorticated structures were occasionally referred to above with the obvious intention that these should be contrasted with corticated types whose thalli are more complicated. The cortex consists of a single or several layers of small cells forming a more or less continous peripheral tissue and masking the core-filaments; it arises as single cells or filaments differentiated from the core-tissue.

Such corticated pseudoparanchymatous forms are extremely common among seaweeds. The corticated structure can only be resolved by microscopic study.

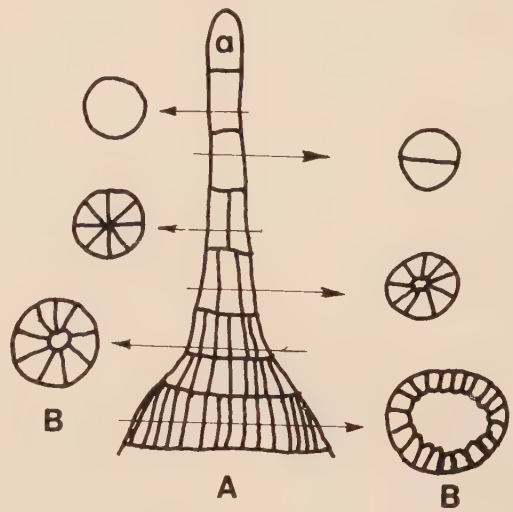
Parenchyma – The final, basic type of thallus to consider is true parenchyma. Thalli as complicated as *Ecklonia maxima* (Fig. 54) and *Sargassum heterophyllum* (Fig. 83) are primarily parenchymatous, as are also other seaweeds like *Ulva* species (Figs. 4 and 5) whose shapes and forms are relatively simple. Parenchyma is very often derived through the process of polystichy. In polystichy longitudinal septation occurs in the cells of a uniseriate filament, which means that all the cells forming the resulting tissue are subdivisions of a single, primary, apical cell.

The morphology of a parenchymatous thallus ultimately depends on the number of planes in which segmentation occurs and on the extent to which cell division occurs in those planes. Thus, the cells of *Porphyra capensis* (Bangiales, Bangiophyceae, Rhodophyta – Fig. 108) initially divide longitudinally in a single plane to yield a monostromatic (single-layered) membrane. All subsequent longitudinal divisions take place in the same plane.



Polystichous development
a: apical cell; 1–1: first-formed septum; 2–2: second-formed septum; 3–3: third-formed septum; 4–4: fourth-formed septum; etc.

Monostroma species (Ulotrichales, Chlorophyta – Fig. 3), too, are monostromatic in their mature forms, although this is a secondary condition derived by the longitudinal schism of an *Enteromorpha*-like vesicle. *Enteromorpha* species (Ulotrichales, Chlorophyta – Fig. 2) initially form uniseriate filaments which undergo a series of anticlinal divisions in a cell some distance behind the distal tip. These divisions result in a transverse plate of cells each of which divides



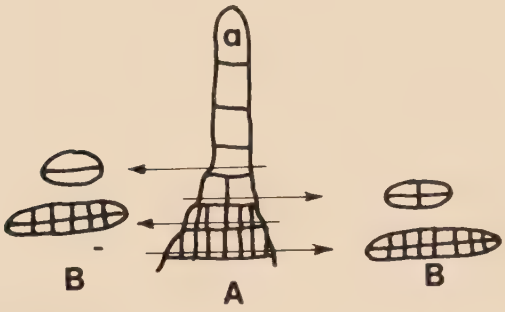
Segmentation in a typical *Enteromorpha* species
A: surface view of primordial tip; B: transverse sections at various distances behind the apical cell
a: apical cell

transversely to form two tiers. The cells of the lower tier separate at the centre under pressure induced by repeated anticlinal septation, and a ring of cells results. Subsequent anticlinal and transverse segmentations in this ring of cells establish a broadening and lengthening tubular body with a monostromatic skin. An *Enteromorpha*-tube may attain a diameter of several centimetres, but in South Africa the collapsed tubes of *Enteromorpha bulbosa* reach only 25 mm in width. The terminal vestige of the primordial uniseriate filament is soon lost in a developing *Enteromorpha*-thallus and, as often as not, mature tubes are open-ended apically. Maximum diameter of the tube is attained almost immediately tube-formation is initiated.

Enteromorphas are not the only hollow seaweeds, but this quality will be discussed further under a separate heading.

The two-layered (distromatic) foliaceous mem-

brane of *Ulva* species (Ulotrichales, Chlorophyta – Figs. 4 and 5) arises from a primordial uniseriate filament. Somewhere behind the tip of such a developing filament, cells divide vertically to form a biseriate filament. All further longitudinal divisions of these two series of cells are at right-angles to the first and, together with subsequent transverse divisions, a distromatic



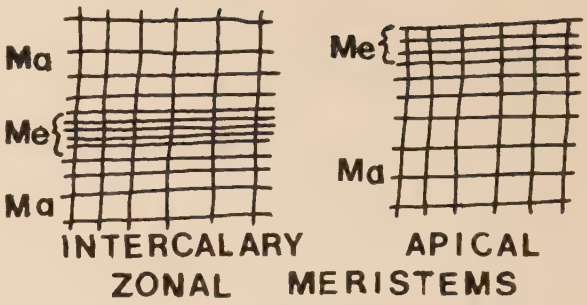
Segmentation in a typical *Ulva* species
A: surface view of primordial tip; B: transverse sections at various distances behind the apical cell
a: apical cell

membrane is established. Like the developing *Enteromorpha,* maturing ulvas soon shed the primordial uniseriate terminal filament.

Attachment of these ulotrichalean types and of *Porphyra,* incidentally, is achieved through the development of haustoria-like extensions of positively geonastic response from proximal cells of the thallus. These extensions adhere to suitable substrata.

Segmentation in all the forms so far discussed occurs anywhere in the thallus, but this is not the case in some other parenchymatous forms such as *Zonaria, Dictyota* (Dictyotales, Phaeophyta), Laminariales and most Fucales, where meristematic tissue has specific location.

Zonarias (Figs. 61 and 62) and laminarians (for example *Laminaria pallida* – Fig. 53) have their meristematic zones located in a transverse band of tissue; in zonarias this band is situated along the distal margin, whereas in Laminariales the band is intercalary and far behind the distal margins of their mature thalli. Both in zonarian and laminarian primordia, after a few longitudinal divisions have given rise to a membranous sheet, periclinical, tangential and anticlinical divisions set in to result in a multi-layered, broadly spreading, strap- or fan-shaped thallus. The zonarias remain entirely parenchymatous and little differentiated in their further development,

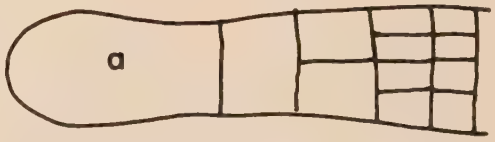


Ma: mature tissue; Me: meristematic tissue

whereas the laminarians become partly pseudoparenchymatous within and morphologically differentiated into distinctive organs. *Durvillea* species (Fucales, Phaeophyta), all from the Subantarctic, like *Laminaria* species are palmate and constructed of both parenchyma and pseudoparenchyma, but unlike them have diffused meristematic activity and fleshy, discoid holdfasts.

Other Fucales, some dictyotalean Algae and members of the Sphacelariales have thalli or, if compound, parts of thalli in which there is a single distinguishable apical cell, differentiated at the (morphologically) distal tip. This cell continues to generate undifferentiated cells throughout the active life of the plant.

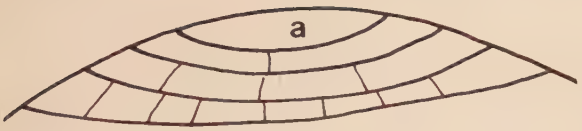
The least complex of these plants with apical cell growth belong in the Order Sphacelariales (Phaeophyta) where the first segmentation plane is transverse resulting in a clearly distinguishable apical cell. This apical cell is relatively large and



Surface view of a thallus with apical cell as primary meristem:
a: apical cell as in the Order Sphacelariales

tends to be darkly pigmented because of the presence of localized deposits of tannin. *Halopteris funicularis* (Fig. 178) and *Phloiocaulon squamulosum* (Fig. 175) are examples of Sphacelariales. Some members of this Order clothe their parenchymatous cores with pseudoparenchymatous tissue or with loose, decurrent threads making a cortex (see above).

Less easily discernible, and then only under a microscope, are the apical cells of *Dictyota species* (Figs. 121 and 122) and *Dictyopteris*



APICAL CELL

Longitudinal section through a growing tip of a thallus with apical cell as primary meristem
a: apical cell as in *Dictyota* species

species (Figs. 85–88), both of the Order Dictyotales (Phaeophyta). Their apical cells are in surface view lens-shaped, and all primary segmentation parallels the inner convex plane. The tissues of these and all other members of the Dictyotales are entirely parenchymatous. Generally, they are morphologically stereotyped forming broad or narrow fans which may be more or less regularly dichotomously branched or haphazardly lacerated.

Most complex of those parenchymatous types having a single apical cell responsible for virtually all growth, are members of the Order Fucales (Phaeophyta). Apical cells, here, are variously shaped as spindles with three sides or truncated pyramids with four sides. The height of these cells is generally greater than the maximum breadth and the long axis of the spindle-shaped apical cell is vertical – not transverse as in *Dictyota*-types – so that in transverse section this cell is an equilateral triangle with convex sides; segmentation occurs on all three sides. Up to five segment-planes may be present in the truncated, four-sided pyramidal apical cell in which the broader end is proximal. Periclinal segmentation parallels at least three of the vertical faces but it may also involve the fourth. In any event, the first segment-plane is transverse in the lower portion of the cell. (The special case of *Durvillea* species, which, although belonging in the Fucales, lack apical cells, has been mentioned along with Laminariales, above.) In those Fucales having an apical cell, such a cell commonly comes to lie in an apical pit or trough.

The above examples by no means include all the parenchymatous South African forms but they do illustrate a range of morphological types.

Trichothallic growth – Trichothallic growth is a habit derived from the primordial uniseriate filament in which meristematic activity becomes limited to a subapical intercalary zone. This intercalary uniseriate meristem produces segments which mature both distally and proximally. Under the microscope, a single terminal hair or brush of hairs is to be seen at a plant's apex. The hair or hairs will be seen to consist, distally, of elongated cells for the most part; near the bases of such hairs the cells shorten and show signs of active division; below this zone of short dividing cells mature and longer cells will again be visible. Such a trichothallic habit characterizes many members of the Order Ectocarpales, all members of both Cutleriales and Desmarestiales, and early stages of thallic development in most members of the Fucales (see below). Both parenchymatous and pseudoparenchymatous thalli may have trichothallic origin.

Growth (meristems)

Frequent reference was made above to locations of cell-division and to meristems or meristematic activity. It will have been realized that cell-divisions occur in meristematic tissues. In Algae, as in higher organisms, some meristems are primary and others have a secondary origin. The diffuse activity which characterizes members of the Ulotrichales (Chlorophyta) and others (mentioned above) involves either entirely embryonic tissue or secondary septation. The apical cell of the primary axis of members of the Fucales is, contrary to expectations, secondarily derived, as it is differentiated in the germling only after a series of haphazard and diffuse segmentations and the emergence of a hair with trichothallic characteristics; the apical cell then appears in the periphery of the parenchymatous tissues with the hair attached to its exposed surface. The hair soon falls off.

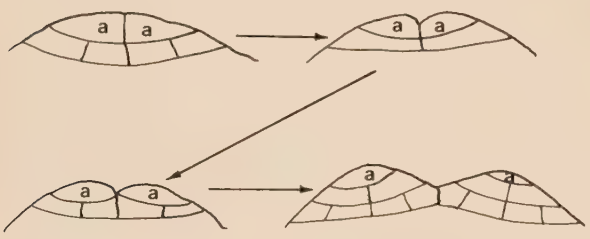
The subapical site of segmentation which characterizes trichothallic growth also locates an intercalary meristem. An intercalary meristem may become laterally extensive (zonal) as in the parenchymatous tissues of the Laminariales or, less spectacularly, in multiaxial (pseudoparenchymatous) thalli such as are possessed by *Papenfussiella* species (Mesogloeaceae, Ectocarpales, Phaeophyta – Fig. 80). Intercalary meristems may exist in uniaxial pseudoparenchymas, too, in which case they are not zonal but involve individual column-cells. Zonal meristems may in some instances have a terminal disposition as, for example, in *Zonaria* (Dictyotales, Phaeophyta) and in Rhodymeniales. Such apical meristems, as they are called, are extremely common in algal thalli of both parenchymatous and pseudoparenchymatous types.

Numerous parenchymatous seaweeds have surface and subsurface meristematic zones in addition to the others they already have. These meristoderms, as they are called, are especially well developed in Laminariales and some Fucales and are responsible for increasing thallic girth rather than extending the plant's length.

Branch-formation

Branching is related to meristematic activity. Branches may or may not resemble the principal axes, and some species, like *Sargassum heterophyllum* (Fig. 83), have a variety of lateral appendages.

Dichotomous forking in thalli is of common occurrence in several members of all seaweed Divisions. In some cases, like *Dictyota* species (Figs. 121 and 122), the forking represents true dichotomy in that both limbs of the fork have exactly the same status and are products of exact

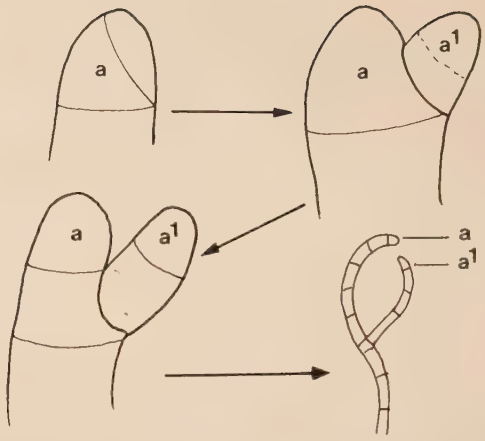


True dichotomy resulting from vertical division of a primary apical cell into two equal segments, each initiating its own segments
a: apical cell as in *Dictyota* species

halves of the parent apical cell. In such cases, the single apical cell undergoes vertical septation yielding two equal daughter cells each destined to act independently.

A pseudodichotomy is characteristic of numerous species. In such an event, diverging limbs have their origins in unequal segments of an apical cell which is divided by an oblique wall. Several species of *Ceramium* (e.g. Figs. 185 – 187) and *Polysiphonia* (e.g. Fig. 182) provide examples of this behaviour.

Polychotomy, either true or false depending on the derivation, involves the production of several equal limbs diverging at a fork and is a characteristic of some species, for example, *Cladophora radiosa* (Fig. 22). In cases where apical, zonal meristems exist, forking may arise

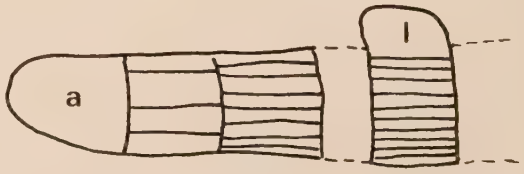


Pseudodichotomy and initiation of an exogenous branch
a: apical cell; a¹: apical cell of a lateral exogenous branch

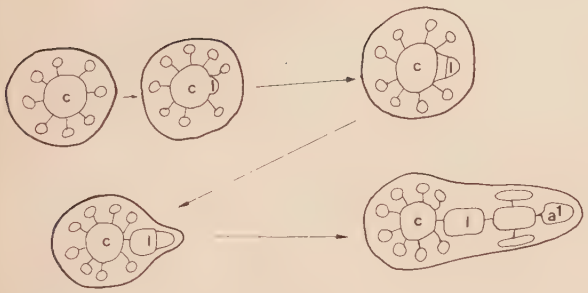
through localized arrest of segmentation at one or several positions in the meristem.

Pseudodichotomy (see above) is a peculiar form of monopodial branching. In monopodial branching it is usual for laterals to show their subordinate status by being less robust than their carriers and by occupying a truly lateral position. The monopodial habit is of frequent occurrence among a wide variety of seaweed species. The laterals may sometimes originate directly from apical cells (or their products, prior to longitudinal division) occurring sometimes by unequal division (see above) or sometimes as lateral shunts from portions of zonal meristems. Other examples of such surface-origins of laterals are provided by those seaweeds which activate, secondarily, single cells or groups of cells to produce branches from mature surfaces of their thalli.

Branching from superficial sources of the sort mentioned above is termed exogenous and contrasts with endogenous branching. Endogenous branching is initiated beneath a surface – usually



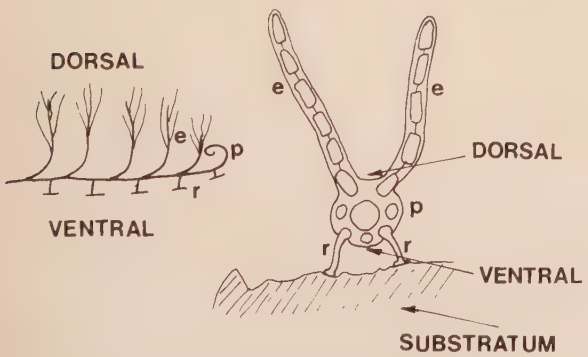
Origin of a lateral not emerging as a pseudodichotomy but nevertheless exogenous
a: apical cell; l: lateral initial



Endogenous branching seen in transverse section of a polysiphonous structure
a¹; apical cell of lateral endogenous branch; c: cell of central column; l: developing lateral endogenous branch

from the central primary axis itself – of a mature portion of the thallus. An endogenous branch forces aside already formed tissue on its way to the surface. Among Rhodomelaceae (Ceramiales) certain Tribes, for example, Lophosiphonieae and Amansieae, possess endogenous branching; other Tribes have only exogenous branching. Thus, for Rhodomelaceae, the presence or absence of endogenous branching has taxonomic significance.

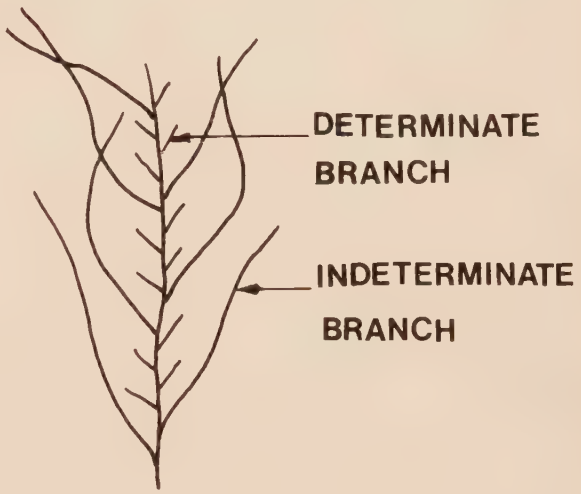
There are other branching characteristics which have a taxonomic importance. The first of these to consider is the condition of dorsiventrality. Once again, it is in the Family Rhodomelaceae (Ceramiales, Rhodophyta) that this possibility must be looked for. Dorsiventrality in a seaweed can be as obvious to an observer as it is in a dicotyledonous leaf, but there are numerous examples of filamentous types, like *Bostrychia* (not illustrated), where such a habit exists and is difficult to determine. The question of dorsiventrality is answered by observing the relative



Dorsiventral construction in a filamentous thallus
e: erect branch; p: creeping branch; r: rhizoid

positions of the branch-insertions. In this connection it is necessary to differentiate rhizoids from laterals – rhizoids are colourless and most often single-celled. A dorsiventral filament has all its laterals inserted in only one half-segment, whereas all rhizoids arise in the opposite half-segment of the parent filament.

A second aspect of branching that has taxonomic significance is that of length. This means that it is necessary to differentiate between determinate and indeterminate extension in length. Determinate branches are often referred to as short (lateral) branches whereas the others are



often called long (lateral) branches. Once again, it is among members of the Family Rhodomelaceae (Ceramiales, Rhodophyta) particularly that these characteristics feature as matters of taxonomic importance. Certain Genera have only long laterals. Thirdly, caulotaxy can be diagnostic for a Genus. Thus, branches may appear oppositely paired, oppositely alternate, bilaterally, radially, or in single spiral to left or right, for example.

All the comments made above about branching refer to the monopodial habit when either di- or polychotomy was not indicated. It is necessary to mention, therefore, that some seaweeds display sympodial development, that is, selected laterals successively take over the function of leading distal growth of the main axis. Among Ceramiales (Rhodophyta), only members of the Family Dasyaceae have a sympodial habit in their vegetative growth. Outside the Ceramiales a sympodial vegetative habit has a less well-defined taxonomic significance.

Calcification

An entire Family, the Corallinaceae, have as their most obvious characteristic heavily calcified thalli. So rich are the deposits of calcium salts in their walls that these plants appear to be made of porcelain. Nevertheless, the Corallinaceae are living, photosynthesizing organisms carrying out all the usual functions of plants. This calcium is present in one or both of two mineral forms, namely, calcite and aragonite. The Corallinaceae seem to contain mainly calcite.

Other Reds, besides some Browns and Greens, build up deposits of calcite or aragonite in their thalli, but none of these ever attains the same degree of hardness, nor are they generally so discoloured by the presence of calcium as are the Corallinaceae. Good examples of such lower levels of calcification are furnished by *Halimeda cuneata* (Siphonales, Chlorophyta – Fig. 6), *Padina* species (Dictyotales, Phaeophyta – e.g. Fig. 58) and *Galaxaura diessingiana* (Nemaliales, Rhodophyta – Fig. 112).

A characteristic of most erect-growing calcified thalli is that they are ringed by narrow, uncalcified girdles at fairly close intervals; presumably this banding is necessary to allow elongated axes to flex under the stresses imposed by strong surf.

Hollow thalli

Hollow thalli are not uncommon among seaweeds but, except for *Enteromorpha* or *Monostroma* which are described above under parenchymatous tissues, they do not have monostromatic skins.

Thus, *Chaetangium ovale* (Nemaliales, Florideophyceae, Rhodophyta – Fig. 47) has a polystromatic skin and is basically a multiseriate pseudoparenchyma.

The polystromatic skins of hollow *Colpomenia sinuosa* (Encoeliaceae, Ectocarpales, Phaeophyta – Fig. 49) and *Scytosiphon lomentarius* (Asperococcaceae, Ectocarpales, Phaeophyta – Fig. 138) are parenchymatous structures.

Champia lumbricalis (Fig. 144) and *Chylocladia capensis* (Fig. 143), both members of the Lomentariaceae of the Order Rhodymeniales (Florideophyceae, Rhodophyta), are multiseriate, pseudoparenchymatous forms with polystromatic skins surrounding hollows interrupted at regular intervals by transverse bands (diaphragms) of cells.

There are, besides the above thalli, those that have specific portions hollowed and vapour-filled. Such vesicles occur in *Macrocystis angustifolia* (Lessioniaceae, Laminariales, Phaeophyta – Fig. 56), *Botryocladia madagascariensis* (Rhodymeniaceae, Rhodymeniales, Florideophyceae, Rhodophyta – Fig. 162) and *Sargassum* species (Sargassaceae, Fucales, Phaeophyta – e.g. Figs. 83 and 84). All these vesicles have multilayered skins, but in the Brown species they are basically parenchymatous tissues, whereas in *Botryocladia* they are pseudoparenchymatous.

Diagnostic application

Before ending this section on structure it should be pointed out that external appearances and structural characteristics together have definite supergeneric diagnostic value for Green and Brown Algae. For Reds, these characteristics are always useful for specific identifications once generic affiliations have been established through the means indicated below under reproductive features.

There are many other vegetative features which could be mentioned and discussed, including the colourless, microscopic trichoblasts so often present in members of the Rhodomelaceae (Ceramiales, Rhodophyta), but they would overburden this basic information with excessive detail.

LIFE-CYCLES AND REPRODUCTION

To understand what follows, the reader must be familiar with certain basic biological concepts and terminology.

Firstly, life-processes are controlled by genetic material usually contained in biological nuclei (cell-nuclei). Secondly, these microscopic nuclei each contain a number of discrete chromosomes which are templates for a particular pattern of genetic material. Thirdly, permutations of genetic material are virtually infinite and no two chromosomes in nuclei of distinct species need be exactly alike. Fourthly, all nuclei present within the non-reproductive, body (somatic) tissues of a single organism are replicates of each other in terms both of number and kind of chromosomes.

Chromosomal quality is repeated in all individuals of the same species; chromosomal number may be either haploid or diploid. A haploid

nucleus contains no two chromosomes alike and is characteristic of sexed reproductive cells. A haploid chromosomal complement constitutes a set basic for the species; diploid nuclei each contain two basic sets of chromosomes. All highly evolved organisms have all their somatic nuclei in the diploid state. For them the haploid state exists only in propagative (reproductive) cells – that is, haploid cells prepared in special tissues for the sole purpose of uniting with other haploid propagative cells, thus returning the diploid state. In more lowly organisms, including almost all thalloid Algae, somatic tissues can be either haploid or diploid. The haploid and diploid phases are connected with each other through the biological processes of reduction division (meiosis) and fertilization (conjugation). The union of two propagative haploid cells to form a single diploid cell with a double set of chromosomes constitutes fertilization; the distribution of a double set of chromosomes among daughter nuclei each containing one set of chromosomes constitutes reduction division (characteristically, four haploid nuclei result from a meiotic division).

Life-cycles

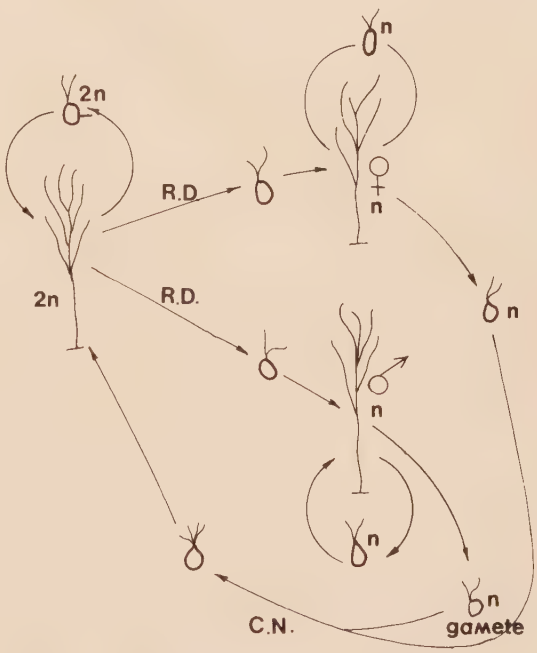
Many Algae delay fertilization (or conjugation) between propagative cells by interpolating thallic, haploid generations. The sequence in which haploid and diploid thalli of a single species follow each other constitutes a lifecycle.

Before discussing particular examples, it must be pointed out that knowledge of life-cycles is very often circumstantial. It is assumed, for instance, that individual plants which differ from one another essentially only in the type of reproductive body they produce, have a common derivation and, therefore, represent the same species; otherwise, understanding is gained by painstaking culture carried out under strictly controlled laboratory conditions. The results of such culture are presumed to be duplicated in nature.

Cycling behaviour of most Greens has not been thoroughly investigated and, as a result, opinions are not very emphatic about the taxonomic importance that this may have. For the Brown Algae, there is a high degree of confidence about cycling behaviour and many an authority concerned with this Division accepts that the three distinct patterns exhibited by the Browns represent three lines of descent. This view was followed by Papenfuss (1951), for instance, where he accepted three Classes, namely, Isogeneratae, Heterogeneratae and Cyclosporeae. Lastly, the Rhodophyta show at least three types of cycle which are not related directly to the subdivision into the two Classes, Bangiophyceae and Florideophyceae.

In the discussion below, the gametophyte is understood to be the free-living, thallic, haploid generation, whereas the sporophyte is the free-living, diploid generation.

Non-cyclic behaviour – Seaweeds least developed in terms of evolution behave haphazardly in their sequences of haploid and diploid generations. In these plants, gametophyte may reproduce gametophyte or sporophyte reproduce sporophyte repeatedly before there is interpolation of the alternative generation. Many species

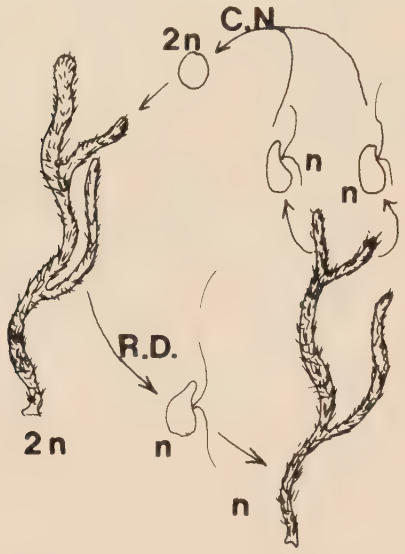


Algal life-cycles: non-cyclic
C.N.: conjugation; n: haploid; 2n: diploid; R.D.: reduction division

acting like this belong in the Order Ectocarpales (Phaeophyta), and, apparently, in the Class Bangiophyceae (Rhodophyta). To what extent such non-cyclic behaviour occurs in Green Algae is not at all well known.

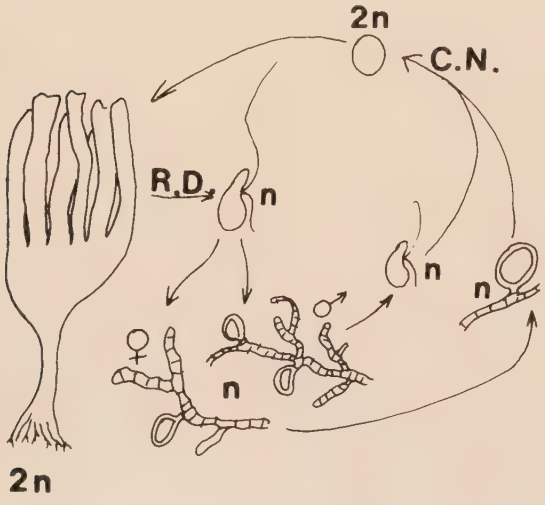
Alternation of generations – This implies a strict succession of gametophyte through sporophyte to gametophyte, and many Brown Algae are the

best-known followers of this pattern. Two types of alternation have been observed: one in which the two generations are morphologically identical – isomorphic – and the second in which the



Algal life-cycles: isomorphic alternation of generations
C.N.: conjugation; n: haploid; 2n: diploid; R.D.: reduction division

gametophyte is entirely different from the sporophyte – heteromorphic.



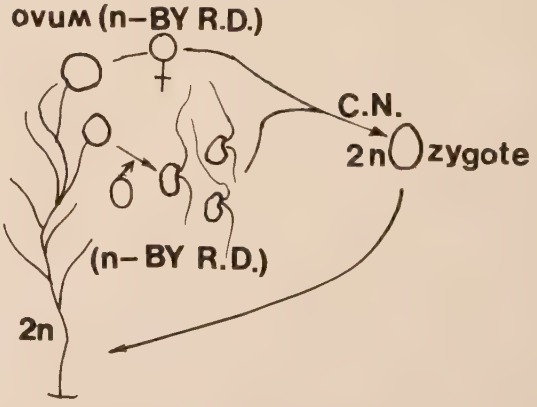
Algal life-cycles: heteromorphic alternation of generations
C.N.: conjugation; n: haploid; 2n: diploid; R.D.: reduction division

Among Red Algae, species which possibly display alternation of generations belong in the Order Bangiales (Bangiophyceae). Thus, *Porphyra capensis* (Fig. 108), so far as is known, has a heteromorphic alternation involving a macroscopic, foliaceous gametophyte and a microscopic, filamentous sporophyte. Some species of the Phyllophoraceae (Gigartinales, Florideophyceae) differ from most other members of their Order by having an alternation of generations (see under Diplobionty below). *Ecklonia maxima* (Laminariales – Fig. 54), typifies the heteromorphic style of alternation so frequently occurring in Brown Algae; here, a macroscopic, structurally complex sporophyte alternates with a microscopic, filamentous gametophytic generation.

Dictyota dichotoma (Dictyotales, Phaeophyta – Fig. 121) and, probably, *Cladophora capensis* (Cladophorales, Chlorophyta – Fig. 21) illustrate the isomorphic type of alternation.

To summarize the occurrence of alternation of generations so far as is known, it can be said, firstly, that perhaps all Green seaweeds in South Africa display isomorphic alternation, secondly, that all members of the Orders Laminariales and Sporochnales and perhaps a few members of the Order Ectocarpales, in the Brown Algae, have a heteromorphic alternation, thirdly, that Brown seaweeds belonging in Sphacelariales and Dictyotales, together with some Ectocarpales, have isomorphic alternation, and lastly, that few Red algal species, mostly in Bangiales (Bangiophyceae), notably *Porphyra* species, have alternation of heteromorphic generations.

Cyclospory – The Fucales (Phaeophyta) have no gametophytic generation. Mature thalli of

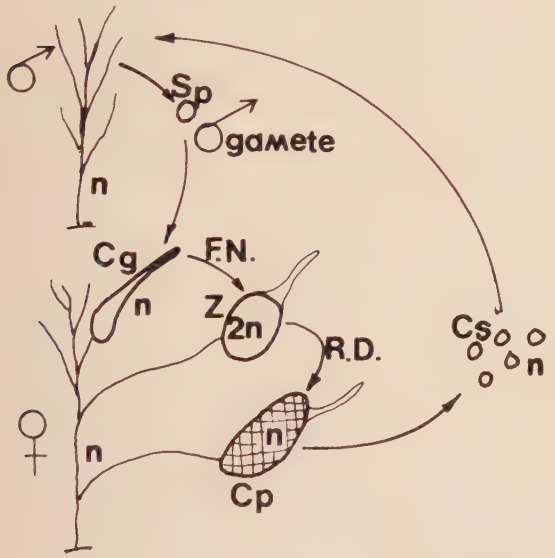


Algal life-cycles: cyclospory
n: haploid; 2n: diploid; R.D.: reduction division

Bifurcariopsis capensis (Fig. 136), for example, are diploid, reproducing through haploid propagative cells produced by reduction division. These propagative cells conjugate in pairs to form diploid zygotes which return sporophytes.

This life-cyclic behaviour is not known to occur in Red Algae but it may take place in some Greens. A cyclospory involving thallic gametophytes and unicellular zygotes which undergo reduction division before generating new gametophytes is a possibility among certain Green Algae.

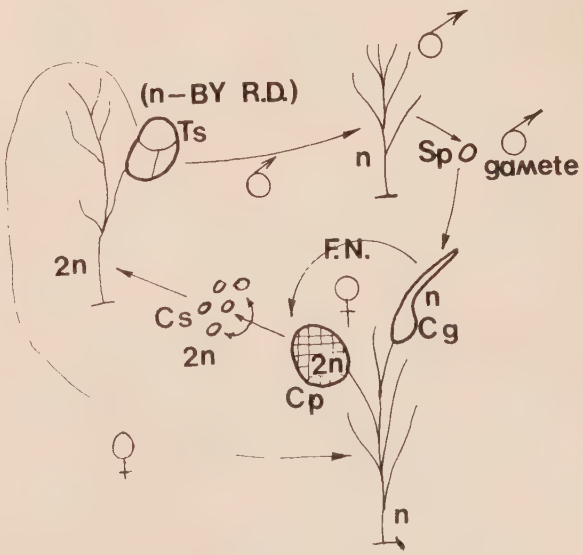
Haplobionty – This term defines a life-cycle thought to be peculiar to members of the Order Nemaliales (Rhodophyta). In this cycle there are two haploid generations alternating with each other and no diploid generation. The gametophytic generation consists of free-living, independent male and female thalli. Following fertilization the zygote generates, in situ, a haploid, microscopic, parasitic generation (the carposporophyte) after undergoing a reduction division. The reproductive cells (carpospores) produced by this carposporophyte are haploid and, after release, return separate male and female gametophytes.



Algal life-cycles: haplobionty
Cg: carpogonium; Cp: carposporophyte; Cs: carpospores; F.N.: fertilization; n: haploid; 2n: diploid; R.D.: reduction division; Sp: spermatium; Z: zygote

During the past fifteen years, life-cycle studies of some of the Nemaliales have revealed a rather different story and one which is more in keeping with the theory of the diplobiontic cycle to be described below. One of the reasons for the long-held belief in haplobionty is, almost certainly, the morphological differences that seem to exist between the gametophytic and sporophytic generations as are indicated by the cycles of such Nemaliales as have been thoroughly examined. The suggested polymorphy in the life-history of these members of the Red Algae was never suspected because of the almost absolute consistency with which most members of the Florideophyceae (Rhodophyta) display dimorphy (gametophytes and sporophytes have similar morphology but are different from the parasitic carposporophytes). Chromosome-counts in algal nuclei are not very easily obtained so that such a method for establishing nuclear ploidy was seldom used or attempted.

Diplobionty – In this life-cycle the zygote (a fertilized female propagative cell) generates diploid reproductive cells (carpospores) via a parasitic, microscopic carposporophyte without undergoing reduction division. Carpospores, after release, develop into free-living sporophytes. Mature sporophytes produce reproductive cells by reduction division. Each of these



Algal life-cycles: diplobionty
Cg: carpogonium; Cp: carposporophyte; Cs: carpospores; F.N.: fertilization; n: haploid; 2n: diploid; R.D.: reduction division; Sp: spermatium; Ts: tetraspores encased in a tetrasporangium; Z: zygote

(haploid) reproductive cells generates either a male or a female gametophyte. With few exceptions, the sporophytes of the relevant species produce packets of four (tetra-) spores (see Sporogenesis below) in each mother cell and are, therefore, known as tetrasporophytes.

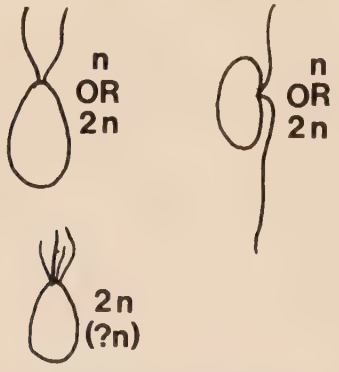
The vast majority of Florideophyceae, including many of the Nemaliales previously thought to display haplobionty, appear to cycle in a diplobiontic manner; a very few species, mostly members of the Family Phyllophoraceae, produce tetraspores on the carposporophyte thus eliminating the free-living sporophytic generation. The diplobiontic cycle apparently does not occur in any other algal Division.

Whatever life-cycle an Alga may have, propagation is usually achieved through spores which is the name by which algal propagative cells are known.

Sporogenesis

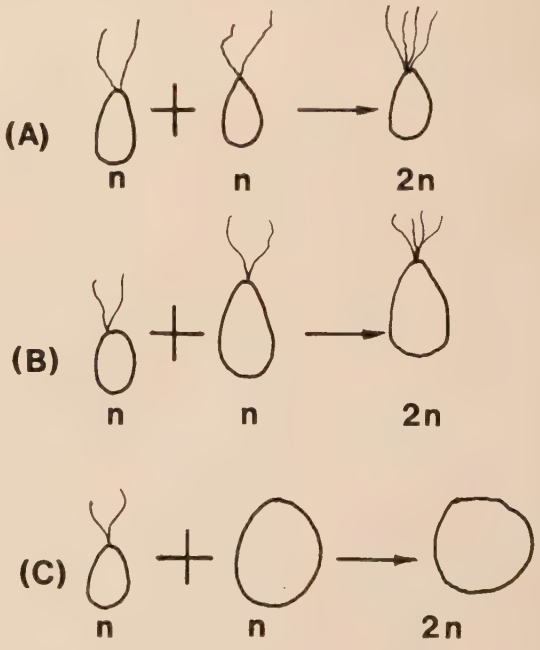
Spores – A spore is, generally, microscopic, uninucleate and naked (that is, the cellulose-material covering the protoplast of most plant cells is missing). The spores of both Green and Brown Algae are generally flagellated and, therefore, motile, but those of Reds are non-flagellated and non-motile. The flagella of the Greens are inserted at the anterior, narrow tip of the pear-shaped spore, whereas those of the similarly shaped spores of Brown Algae are laterally inserted. Most spores, unless they have conjugated, have only two flagella.

Spores are either haploid or diploid, are produced within specialized cells called sporangia and have a variety of names given to them. The name given depends sometimes on the spore's behaviour and/or sometimes on its origins. Thus, a gamete is a haploid spore requiring to conjugate with another in order to fulfil its destiny; gametes derive from a gametangium; and a tetrasporangium yields, by reduction division, tetraspores which as the name implies arise in packages of four.



Spores of Green and Brown Algae
n: haploid; 2n: diploid

Oogamy – Non-motile female spores are characteristic of oogamy, a process in which female gametes are retained by sporangia during fertilization. Such female spores (ova) are contained in sporangia called oogonia (Greens and Browns) or carpogonia (Reds). Carpogonia differ from the more or less egg-shaped oogonia of Greens and Browns by having at one end a narrow stigma-like neck, the trichogyne, which serves as a male gamete receptor. The motile, male gametes participating in oogamy in Brown and Green Algae are called either antherozoids or spermatozoids and are produced in antheridia; non-motile male gametes of Rhodophyta are called spermatia and are produced in sporangia called either antheridia or spermatangia.



Spores of Green and Brown Algae: fertilization of gametes
A: isogamy; B: anisogamy; C: oogamy
n: haploid; 2n: diploid

Isogamy and anisogamy – Where both motile gametes participating in fertilization are of equal or scarcely different size, isogamy is said to occur. Where this is not the case, anisogamy exists. Motile gametes, in any event, are produced within gametangia.

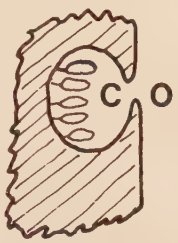
Brown Algae having iso- or anisogamy belong in any one of the Orders Ectocarpales, Cutleriales, Tilopteridales (not represented in South Africa) and Sphacelariales. The other five Orders of Phaeophyta (see Classification Scheme) have oogamy.

Sori – Individual sporangia are microscopic but they may be clustered together to form a sorus and then possibly betray their presence either to the naked eye or under low magnification. Sori may appear as measly spots, low mounds, ridges or warty protuberances rising above the general surface; sometimes, indeed, they arise only on macroscopic specialized laterals which can be easily recognized. Although it is possible that features such as those mentioned may indicate reproductive tissue, they may equally well be purely vegetative in character; their true nature can be diagnosed only under microscopic examination.

Superficial sori occur in a variety of Browns, especially members of Dictyotales and Laminariales. Sori are not found in Greens, but in the Reds tetrasporangia and antheridia may cluster into small or very extensive soral groups. It sometimes happens both in Reds and Browns that sori are produced only in or on special axes, called sporangiophores (if spermatia-producers, then spermatangiophores or antheridiophores). Sporangiophores are sometimes clearly visible in members of the Sporochnales (Phaeophyta) and in the stichidia of numerous Reds such as *Hypnea spicifera* (Figs. 45 and 158) and *Dasya* species (Fig. 181).

Cystocarps – Female plants of many Red Algae have submacroscopic, wart-like (*Gracilaria verrucosa* – Fig. 159) or flask-shaped (*Polysiphonia* species – e.g. Fig. 182) cystocarps protruding from their surfaces. Such cystocarps contain a carposporophyte (parasitic, diploid plant – see Life-cycles above) and may or may not open to the hydrosphere through a pore (ostiole). Ostioles result sometimes from local disintegration, sometimes by rupture of cells in the covering tissue or sometimes from incomplete overgrowth of sterile tissue. The cystocarpic wall consists of host-tissues and is, therefore, haploid. The macrophyte carrying the cystocarps is often loosely but incorrectly called a cystocarpic plant.

Conceptacles – Another type of sporangial container, which like the cystocarpic wall consists of vegetative tissue, is the pit-like conceptacle featured by Fucales (Phaeophyta), *Splachnidium rugosum* (Ectocarpales, Phaeophyta – Fig. 52) and Corallinaceae (Cryptonemiales, Rhodophyta). Such conceptacles have their walls lined with numerous sporangia; they are sori with protection afforded by massive overgrowth of surrounding tissue. Conceptacles always open to

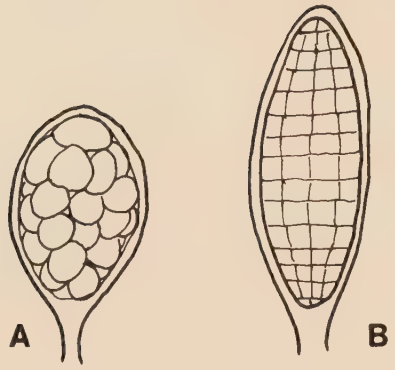


Conceptacle: longitudinal section
C: conceptacle lined with sporangia; O: ostiole or pore

the hydrosphere through pores. Although conceptacles may appear like cystocarps, they are differently derived and may contain any type of Red algal spore.

Oogonia and antheridia – Continuing the theme of nomenclature applied to spores and sporangia, it is necessary, first, to recall the oogonia and antheridia mentioned above. The names oogonia and antheridia are applied in Greens and especially Browns because of the behaviour of their spores rather than because of the mechanisms by which their spores originate. Thus, ova and spermatozoids may be the result of a reduction division (Fucales) or not (other oogamous Browns). Such nomenclatural anomalies are bound to occur even in the best devised systematic scheme. Thus, the alternative names of unilocular and plurilocular sporangia present difficulties because, irrespective of the mechanism by which they derive their spores, monosporous sporangia are unilocular by definition.

Uni- and plurilocular sporangia – Evidence of their occurrence and behaviour strongly favours the view that those unilocular (aseptate) sporangia which produce four or more spores do so through reduction division; on the other hand, plurilocular sporangia, in which contained spores are separated from one another by walls



Sporangia
A: unilocular; B: plurilocular

(septate) are specialized (effectively vegetative) parenchymatous tissues each of whose cells produce and release single propagative cells (spores). The unilocular sporangia of Dictyotales produce four asexual spores (tetraspores) by reduction division, while their antheridia and oogania are plurilocular, containing haploid sexed spores. By contrast, the oogonia and antheridia of the Fucales are unilocular and their spores haploid, a condition achieved through reduction division of diploid somatic cells. Although oogonia and antheridia of Laminariales each produce a single gamete in a non-septate chamber, it would seem justifiable to consider laminarian oogonia and antheridia homologous with plurilocular sporangia: supporting evidence for such an interpretation comes from the fact that the bulky, diploid, laminarian sporophytes bear unilocular (aseptate) sporangia whose many spores individually produce the microscopic haploid gametophytes that generate oogonia and antheridia.

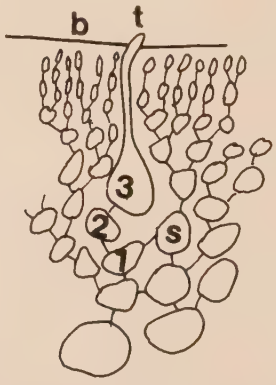
Sporangial types of the Rhodophyta, for the most part, have different names. It has already been mentioned that the (female) carpogonium of the Reds is a type of oogonium (but see below) and that the term antheridium is, where appropriate (i.e. where oogamy occurs), applied to male sporangia in both Reds and Browns. The rhodophytan carpogonium and antheridium are perhaps homologous with the oogonium and antheridium of laminarians in that they are plurilocular sporangia modified to contain only one spore each, since they are produced by haploid thalli. Some doubt exists about the homology suggested here, because many authorities (Kylin 1956, included) are of the opinion that carpogonia and antheridia are each binucleate, which is in contrast to the uninucleate antherozoids and ova of, for instance, the Laminariales. No such objection can be raised against the homology of the respective tetrasporangia of Florideophyceae (Rhodophyta) and of Dictyotales (Phaeophyta).

Whatever may be their true application, the epithets unilocular and plurilocular are generally reserved for describing single- and many-chambered sporangia possessed by members of the Brown Algae and refer more particularly to members of the Ectocarpales, Sphacelariales and a few Genera outside these two Orders.

Both single- and many-chambered sporangia of Green Algae releasing spores which conjugate in pairs are called gametangia; if, however, their spores individually generate thalli, both types of sporangium are termed zoosporangia. The terms unilocular and plurilocular sporangia are, therefore, not used for Greens.

Carpogonia – To discuss spores and sporangia of Algae without referring to the somewhat complicated pre- and post-fertilization histories of carpogonia in Florideophyceae would be a serious omission, especially since these histories determine the natural interrelationships between members of the group. I do not, however, wish to go into more detail than is necessary to provide basic understanding of the processes involved and of the results generated. The features referred to are all to be resolved only through painstaking microscopic study.

A carpogonium itself is a flask-shaped structure with, generally, an elongated neck (trichogyne) which may or may not be contorted. With very few exceptions, the carpogonium consti-



Spores of Red Algae: female organ (carpogonium) and associated parts
1, 2 and 3: carpogonial branch; 3: carpogonium; b: surface of tissue; s: supporting cell; t: trichogyne

tutes the end-cell of a short uniseriate filament (the carpogonial branch) which may be so reduced as to consist of the carpogonium only.

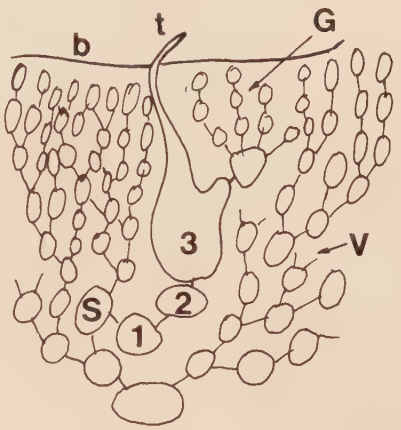
Carpogonial branch – The number of cells in a carpogonial branch is usually a characteristic of the Genus, Family or Order. Thus, in the Family Gelidiaceae, the carpogonial branch consists of the carpogonium alone, while in the Order Ceramiales there are always four cells; in *Galaxaura* and *Chaetangium* (both Genera of the Family Chaetangiaceae) there are carpogonial branches of three or four cells, respectively; carpogonial branches of members of the Family Plocamiaceae are three-celled as are also those of members of two or three other Families in this Order (Gigartinales). In some Genera the carpogonial branch may consist of up to 11 cells; it may sometimes be extensively and pinnately branched. Branches of carpogonial branches may, rarely, themselves produce carpogonia.

The vegetative cell carrying the carpogonial branch is called the supporting cell ("Tragzelle" – Kylin 1956 and others). In some Species and Genera a supporting cell may produce more than one carpogonial branch (e.g. *Kallymenia* species).

Gonimoblast-development and auxiliary cell – After it has been fertilized, a carpogonium may directly produce the carposporophyte, consisting of so-called gonimoblast filaments, or it may do so indirectly from another cell with which it establishes a connection, namely an auxiliary cell. This auxiliary cell is a vegetative cell and, through its contact with surrounding vegetative tissue, is presumed to be in a position to transfer nourishment necessary for developing the carposporophyte.

Taxonomic significance of gonimoblast-development – Kylin has advocated that the term auxiliary cell be reserved for a participating vegetative cell situated outside the carpogonial branch itself and he includes the possibility of the supporting cell acting in this capacity. Kylin requires further that the auxiliary cell and not the carpogonium should produce the gonimoblasts. These restrictions have led to difficulties of interpretation which cannot easily be dismissed, especially since some of the premises on which Kylin based his opinions have been refuted. This, however, is not the place to enter into discussion on the finer points of taxonomy and, except to mention that there are other arguments (Dixon 1973, and others), I am giving Kylin's (1956) version here, simply because his is included in the most comprehensive contemporary treatment of the Rhodophyta available.

According to Kylin, true auxiliary cells do not exist in either Gelidiales (=Gelidiaceae, Nemaliales, according to the appended classification scheme) or Nemaliales. Such cell-fusions as may occur in these two Orders are confined sometimes to cells of the carpogonial branch itself (Nemaliales), sometimes to lateral branches of

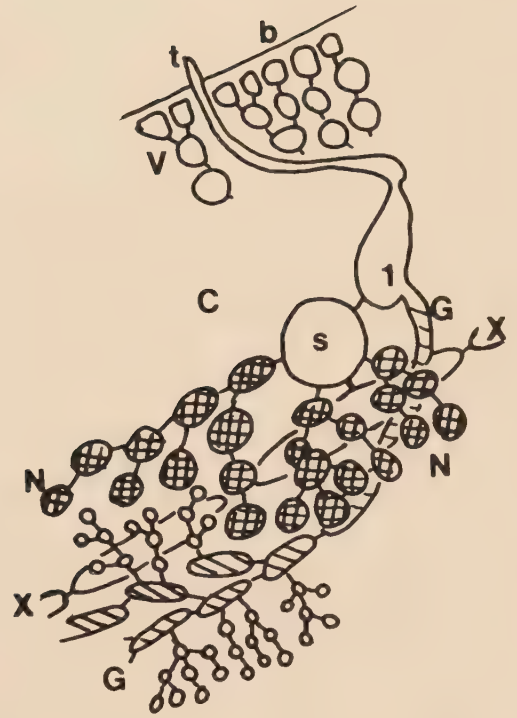


Spores of Red Algae (Nemaliales): gonimoblast development in relation to the carpogonium (3)
1, 2 and 3: carpogonial branch; 3: carpogonium; b: surface of tissue; G: gonimoblast tissue (diploid); s: supporting cell; t: trichogyne; V: vegetative tissue (haploid)

the carpogonial branch (Nemaliales), or lastly, to special nutritive cells carried as filaments on the supporting cells of several carpogonia produced in a special fertile zone (Gelidiales). In both Orders the carpogonia themselves are supposed to generate gonimoblasts, but this is not consistently the case.

The remaining four orders recognized by Kylin, namely Cryptonemiales, Gigartinales, Rhodymeniales and Ceramiales are acknowledged by most contemporary algal taxonomists and all have true auxiliary cells in the sense of Kylin. The anatomical siting of the auxiliaries distinguishes members of the various Orders.

The Cryptonemiales produce auxiliaries only within a cluster of secondary accessory filaments; Gigartinales have any *intercalary* vegetative cell (including the supporting cell) acting as auxiliary; and the auxiliaries of the last two Orders, namely, Rhodymeniales and Ceramiales, are *apical* cells of filaments produced directly (Ceramiales) or indirectly (Rhodymeniales) on

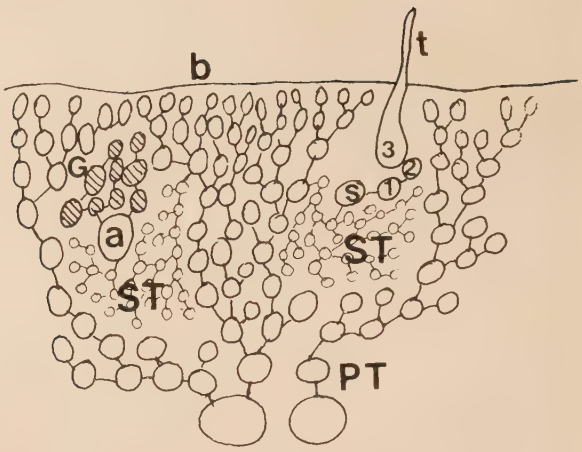


Spores of Red Algae (Gelidiales sensu Kylin): gonimoblast development in relation to the carpogonium (1)

1: carpogonium and only cell in the carpogonial branch; b: surface of tissue; C: cavity for sporogenous tissue; G: gonimoblast filaments (diploid) N: nutritive tissue; s: supporting cell; V: vegetative tissue (haploid); X–X: axis of central column cells

the supporting cell. Thus, for Ceramiales, immediately *following* fertilization, the supporting cell cuts off between one and three single-celled laterals to act as auxiliary cells. Members of the Rhodymeniales produce auxiliaries *before* fertilization on sterile branches of the supporting cell; each auxiliary is a single-celled lateral of the basal cell of such a sterile branch.

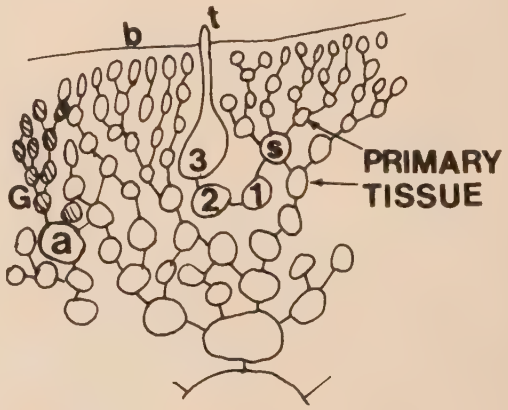
Where a carpogonium and its auxiliary cell emanate from the same supporting cell, a procarp is said to exist. It should be apparent that all members of both Orders, Ceramiales and Rhodymeniales, feature procarpic structures; Gigartinales and Cryptonemiales have members that are either procarpic or non-procarpic. In non-procarpic species auxiliaries may be remote from the carpogonia they serve. Such remoteness requires that elongated connecting filaments make the necessary contact. Nevertheless, as a rule gonimoblasts emerge from the operative auxiliary cells and not from the carpogonia; in one Family, the Cruoriaceae of the Order Gigartinales, the gonimoblasts are generated by the connecting filaments and not by the auxiliaries.



Spores of Red Algae (Cryptonemiales): non-procarpic structure – gonimoblast development in relation to the carpogonium (3)

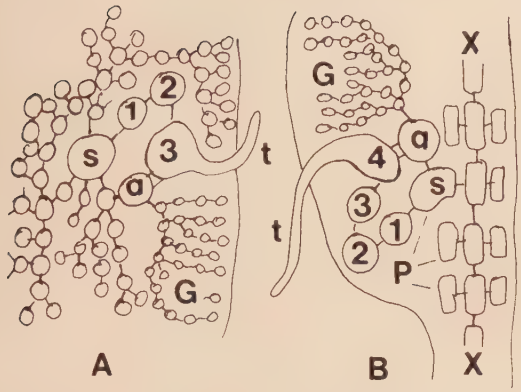
1, 2 and 3: carpogonial branch; 3: carpogonium; a: auxiliary cell; b: surface of tissue; G: gonimoblast tissue (diploid); PT: primary vegetative tissue (haploid); s: supporting cell; ST: secondary or accessory vegetative tissue (haploid)

It should be noted that fusion of the fertilized carpogonium with other cells of the carpogonial

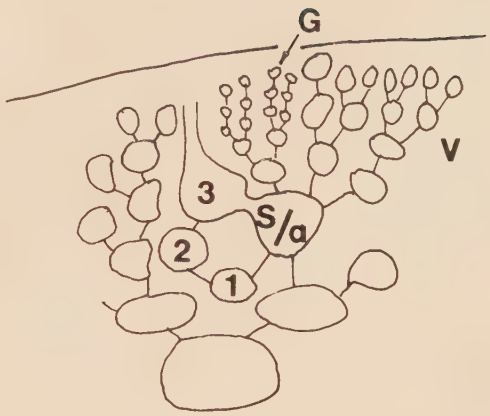


Spores of Red Algae (Gigartinales): non-procarpic structure – gonimoblast development in relation to the carpogonium (3)

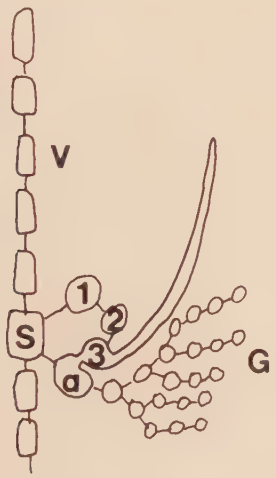
1, 2 and 3: carpogonial branch; 3: carpogonium; a: auxiliary cell; b: surface of tissue; G: gominoblast tissue (diploid); s: supporting cell; t: trichogyne; Primary tissue is haploid



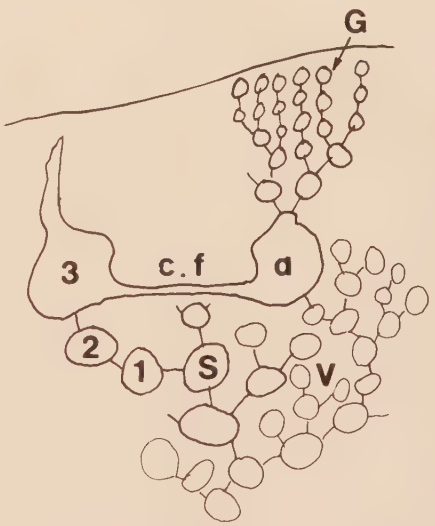
Spores of Red Algae: gonimoblast development in relation to the carpogonium
A: Rhodymeniales; B: Ceramiales
1–3/4 carpogonial branch; a: auxiliary cell; G: gonimoblast tissue (diploid); P: pericentral cell; s: supporting cell; t: trichogyne; X–X: central column of polysiphonous construction (haploid)



Spores of Red Algae (Gigartinales): a procarpic structure
1, 2 and 3: carpogonial branch; a/s: supporting cell doubling as the auxiliary cell; G: gonimoblast tissue (diploid); V: vegetative tissue (haploid)



Spores of Red Algae: stylized procarpic structure
1, 2 and 3: carpogonial branch; 3: carpogonium; a: auxiliary cell; G: gonimoblast tissue (diploid); s: supporting cell; V: vegetative tissue (haploid)



Spores of Red Algae (Gigartinales): a non-procarpic structure
1, 2 and 3: carpogonial branch; 3: carpogonium; a: auxiliary cell; c.f.: connecting filament; G: gonimoblast tissue (diploid); s: supporting cell; V: vegetative tissue (haploid)

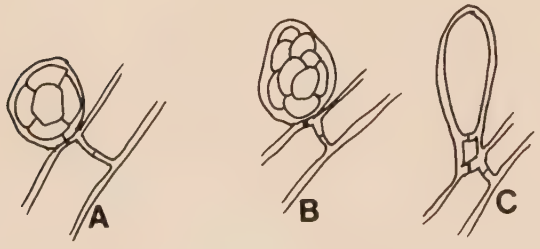
branch is a common occurrence in procarpic Florideophyceae and all Nemaliales (including Kylin's Gelidiales); integration with the auxiliary may also take place in procarpic forms. The auxiliary cell in non-procarpic types may fuse with neighbouring vegetative cells.

Carposporophytes, when mature, form usually densely compact filamentous structures; these are sometimes scattered haphazardly through the tissues of the host-plant (in this case, the female gametophyte), sometimes located only in terminal portions of the host-plant, or sometimes confined to special proliferations on the host. Their microscopic structures vary from one

organism to another, and information as to specific identification or affiliations of the host-plant can sometimes be deduced from these features.

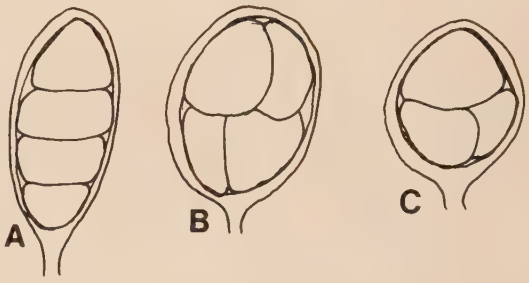
Accompanying the growth of carposporophytes are changes in surrounding vegetative tissues of the host, and the modifications which result may aid an identification – for instance, cystocarps (i.e. the protective containers of carposporophytes) may be distinctive if certain other vegetative features are also present. Because carposporophytic structures provide inconclusive evidence of affiliations, their appearance in section cannot be relied upon for arriving at identifications. Apart, then, from drawing attention to their existence and to the fact that they identify their host as a female gametophyte in which carpogonial structures may be present in various stages of development, carposporophytes need no further comment here.

In addition to tetraspores, carpospores, ova (carpogonia) and spermatia, through whose agencies most Florideophyceae reproduce, some Red Algae of this Class are disseminated through other spore-types; these types include monospores, paraspores and polyspores (see *Aristothamnion collabens* – Fig. 180). These spore-types are not common and their occurrence may characterize some Genera. Thus, the case of *Aristothamnion* species has already been mentioned in connection with polyspore-bearing, a characteristic it shares with the Genus *Pleonosporium*; *Acrochaetium*, a Genus of Nemaliales, is notable for its consistent production of monosporangia. There is some contradiction (Dixon 1973) as to the application of the term paraspore and Kylin's (1956) interpretation should be ignored. Paraspores are in fact irregular clusters of spores formed as an exposed lateral of a filament.



Spores of Red Algae
A: polysporangium; B: parasporangium; C: monosporangium

Finally, comments about tetrasporangia are in order. Firstly, their spores are arranged in one of three patterns: zonate (in a uniseriate row – "quergeteilt" of Kylin, 1956); cruciate (in two rows of two each – "paarig geteilt" of Kylin, 1956), and tetrahedral ("tetraedrisch" of Kylin, 1956). A particular species always has its tetraspores arranged in the same way. For example, *Gigartina radula* (Fig. 126) has a cruciate arrangement; *Corallina* species (Fig. 78) have a zonate arrangement; and *Pterosiphonia cloiophylla* (Fig. 154) has a tetrahedral arrangement. Secondly,



Spores of Red Algae: tetrasporangial division
A: zonate; B: cruciate; C: tetrahedral

tetrasporangia may be dispersed over the surface through the inner tissues, or they may be aggregated in nemathecia or sori. Nemathecia differ from sori by their more massive development of sterile tissue causing sometimes gross distortion of the thallus surface as in cystocarpic swellings.

Reproductive processes in algal taxonomy

In conclusion, it can be said that algal reproduction, its devices and results, are all of the utmost importance in understanding algal interrelationships. This statement is especially true of the female plants of Red Algae. Considerable information has been accumulated since Kylin (1956) presented his extremely useful compendium on Red algal characteristics and natural histories, but much work remains to be done and on a much wider spectrum of species if there is to be any major improvement in the level of our understanding of these organisms. Difficulty in producing information stems to some extent from the very small size of the features which must be examined, but, with better and more frequent use of electron microscopy, this difficulty may largely disappear.

CLASSIFICATION

Principles

The so-called Algae, in which seaweeds are included, were for long considered as a single Plant Division. Most phycological systematists now are of the opinion that the Algae consist of unrelated groups and, therefore, constitute several Divisions.

In spite of the term "Algae" being technically unacceptable, it remains in common use by professional botanists. Thus, the Division Chlorophyta is commonly referred to as Green Algae, the Phaeophyta as Brown Algae, the Rhodophyta as Red Algae, and the Cyanophyta as Blue-Green Algae. These Division-names are, as is done here, often shortened to Greens, Browns, Reds and Blue-Greens. Such a colour-terminology seldom applies to the several other Divisions of Algae.

The various Divisions of Algae have some features in common: thus, they characteristically disseminate through the agency of microscopic spores which are naked, usually uninucleate protoplasts; those Algae that develop into organized plant-bodies (thalli) lack the elaborate conducting vascular tissues which characterize ferns and seed-bearing plants; their unfertilized female gametes (see under Sporogenesis in the section dealing with Life-cycles and Reproduction) are not protected by specially developed vegetative tissue as are those of mosses, which, like Algae, are non-vascular plants; finally, they possess chlorophyll *a*, allowing them to photosynthesize, thus differentiating them from Fungi.

Anatomically, many Algae seem to be comparable with certain Fungi and the similarities once led to the belief that these two groups were closely related. Consequently, a Division Thallophyta was created to contain both Algae and Fungi. Not many authorities are today of the opinion that such a relationship exists and Algae and Fungi are considered as entirely distinct.

The tradition of naming some of the Divisions according to a colour-code is unfortunate, because it leads the uninitiated into the erroneous belief that a seaweed can be placed in its correct Division simply by observing its colour.

The basis of these colour-codes, however, is biochemically sound. Thus, the pigmentation of Green Algae corresponds almost exactly with that possessed by the green leaves of flowering plants; Brown Algae have a characteristic brown xanthophyll-type pigment (some authorities believe it to be a carotenoid-type) called fucoxanthin; Red Algae always contain red phycoerythrin-r and blue phycocyanin-r; the Blue-Green Algae contain phycoerythrin-c (red) and phycocyanin-c (blue); and the Xanthophyceae (Chrysophyta) possess much yellow xanthophyll.

In terms of outward manifestation, the Greens are some shade of green, the Browns are more or less true to type, the Xanthophyceae and Blue-Greens are often green, but the Reds are any of these colours and include, besides, shades of yellow, purple and red.

The few members of the Chrysophyta which form recognizable thalli in South Africa are, so far as is known, members of the Class Bacillariophyceae (diatoms). Two types have so far been encountered. One of these forms sparsely branched, pencil-thick, very flaccidly gelatinous thalli which have a greenish-brown or golden-brown colour. The individual cells making up the colony are closely packed, discernible only when highly magnified, and arranged with their long axes parallel to the lateral margins of the thallus. The second type is more *Cladophora*-like (cf. Figs. 18 to 23) but brownish, and again made up of vast numbers of juxtaposed *Navicula*-type cells.

Of the South African marine Cyanophyta (Blue-Green Algae) little is known. Generally, the thalloid types form mucilaginous wefts of delicate, flaccid filaments of a dark green; morphological details can be discerned only through microscopes, so that hand-lens observation is of little use for identifying them. The cytology and reproduction of the Cyanophyta differ from those of other species in that pigments are dispersed through the cell-contents, no organized nucleus exists, and reproduction appears to be vegetative.

No further reference to either Chrysophyta or Cyanophyta will be made here.

Fritsch (1935 and 1945) treats the Chlorophyta, Phaeophyta and Rhodophyta as three Classes of the Division Algae. In the classification scheme in the present text, Fritsch's two Classes, Chlorophyceae and Phaeophyceae, effectively remain unaltered although allocated to two separate Divisions.

For Rhodophyta the classification scheme which follows is based largely on Kylin's (1956) proposals for the Rhodophyceae (a Class). Once again an elevation of status for Rhodophyceae allows that the Bangioideae and Florideae, Kylin's two Subclasses, be considered as Classes; this systematic arrangement was proposed by Dixon (1973) and is followed here.

All three Divisions, Greens, Browns and Reds, have their photosynthetic pigments contained in chloroplasts, their nuclear material organized into a nucleus with a bounding membrane, and have cell walls containing some cellulose.

Chlorophyta – The Division Chlorophyta contains Algae that not only have the same four pigments in the same proportions as flowering-plants but also have starch as their chief food-storage product. Their chloroplasts commonly contain a single, peculiar, ovoid organelle with a starch-sheath, called a pyrenoid. These Algae reproduce mostly through motile, pear-shaped spores which have two equal flagella inserted at the anterior (narrow) end, although in some species that display sexuality, the female gamete is immobile. (Most of these features, and others to be mentioned, are explained in more detail under the headings of Structure and Development and Life-cycles and Reproduction).

The above characteristics of the Division apply generally to all Chlorophyceae (a Class to which all Greens belong) except members of the Orders Oedogoniales and Conjugales, neither of which contains any seaweeds. Orders and Families within the Chlorophyceae are separated on combinations of characteristics applying to chloroplast shape and ultrastructure, absence or presence of segmentation, type of segmentation, and forms of sexuality (isogamy, anisogamy, oogamy or conjugation – conjugation involves non-motile amoeboid gametes).

Most of these features are discussed in more detail under appropriate headings elsewhere in this work.

As to Chlorophyta, seaweeds belong in only three of Fritsch's Orders, namely, Ulotrichales, Cladophorales and Siphonales.

The Ulotrichales contain Green Algae that have segmented filaments or simple parenchymatous thalli; their chloroplasts occur singly in each cell and are perhaps cup-shaped or parietal discoid or parietal sheath-like, or rarely, stellate; their cells are uninucleate; they reproduce through flagellated spores of the kind typical of the Division and display isogamous sexuality. Their life-cycles have not received concerted attention, but they are probably isomorphic in their alternate generations.

Cladophorales contain only simple or branched uniseriate filamentous types in which the filaments are generally coarse and segmented; their segments each contain two or more nuclei and either a deeply and repeatedly constricted chloroplast or several discoid chloroplasts; they reproduce through typical flagellated spores and display either iso- or anisogamous sexuality; and their life-cycles probably involve alternation of isomorphic (of similar appearance) generations.

Fritsch's Order Siphonales includes Greens that are basically either filamentous or vesiculate – the filamentous types are aseptate except when differentiating sporangia, while the vesiculate types have a peculiar kind of septation called segregative division (see Septation under Structure and Development); many are multinucleate structures and contain numerous discoid chloroplasts but some, like *Acetabularia* species, are uninucleate; reproduction is by flagellated spores of the typical chlorophytan form and involves isogamous sexuality; and their life-cycles probably involve alternation of isomorphic generations.

Phaeophyta – The Brown algal Division characteristically has fucoxanthin as a photosynthetic pigment accessory to the essential chlorophyll *a*; other pigments occurring include chlorophyll *c*, beta-carotene and a few xanthophylls besides fucoxanthin. Their main food reserves are laminarin, mannitol and fats. All Phaeophyta are multicellular and all are septate. Their vegetative cells are uninucleate and, most often, contain several discoid chloroplasts. Reproductive spores are, when motile, pear-shaped and provided with two flagella. The flagella are inserted laterally, together, and are of unequal length; except in Fucales, the longer one projects forwards, propelling the spore, while the shorter trails behind. Life-cycles of many Browns have been followed, and, apart from the erratic performance of some vegetatively simple forms, three patterns of behaviour have emerged, namely, alternation of isomorphic generations, alternation of heteromorphic generations, and cyclospory. In cyclospory only the sporophytic generation is multicellular. Most of these features are explained in previous sections of this work.

Some systematists are of the opinion that the three life-cycling patterns mentioned above segregate the Phaeophyta into three phylogenetic lines deserving the status of Class (or of Subclass, if the authority concerned acknowledges the Brown Algae as a Class). Fritsch rejected this segregation into three categories of equal status, believing that heteromorphy is derived from isomorphy and that characteristics other than the life-cycle have equal evolutionary and, therefore, systematic importance. Having

here elevated the Brown Algae to divisional status a subdivision into Classes is possible; only one Class is recognized in the present text, and this has the characters of the Division.

Although almost all Brown Algae are marine, only seven of Fritsch's nine Orders appear in the appended classification scheme, because the other two are not represented in southern African records.

The characteristics of all nine Orders could be presented here, but it seems better to refer the reader to Fritsch (1945) for these details. Instead, only a few of the more important features will be mentioned.

The Ectocarpales contain filamentous as well as more bulky forms which may be of pseudoparenchymatous or parenchymatous construction. A feature common to many of these plants is trichothallic growth. This trichothallic growth occurs, too, in the Orders Tilopteridales and Cutleriales, but, whereas the Ectocarpales display isogamy, these other two Orders either have marked anisogamy suggesting oogamy (Cutleriales) or produce motionless spores from some sporangia (Tilopteridales). A fourth Order in which trichothallic growth features is the Desmarestiales. The Desmarestiales differ from the others in that they display true oogamy and show extensive secondary intercalary growth besides the primary trichothallic growth.

Of the five remaining Orders recognized by Fritsch (1945) one, the Laminariales, has a true intercalary meristem, and three, namely, Fucales, Dictyotales and Sphacelariales, have apical growth. The Order Sporochnales has a peculiar type of intercalary meristem that shows the features of an apical meristem – distal to which is a cluster of hairs with intercalary meristems. The Sporochnales have only pseudoparenchymatous thalli. The other four Orders mentioned are, primarily, parenchymatous, although only the Dictyotales are entirely so. The apical meristem of the Dictyotales is, depending on the Genus, either multicellular as an arching band of terminal cells, or a single lens-shaped cell with its long axis transverse. Of the Fucales only one Genus, *Durvillea,* deviates from the pattern of a single apical cell generating all the primary tissue of an axis; this cell is more or less trapezoid or, if lens-shaped in longitudinal section, its long axis is vertical. *Durvillea* species generate new cells in any part of their thalli.

The Laminariales and Sporochnales among these five Orders have alternation of heteromorphic life-cycles with microscopic oogamous gametophytes, while the Dictyotales and Sphacelariales have isomorphic alternation. The Fucales are thallic only in the diploid (sporophytic) generation. Both Fucales and Dictyotales display oogamy while Sphacelariales may be either isogamous or anisogamous.

Rhodophyta – The Red Algae are here grouped as a Division consisting of two Classes, Bangiophyceae and Florideophyceae. The organisms in these two Classes seem to have little in common other than pigmentation and non-motile spores; all, however, have floridean starch as a storage product and pyrenoid-like bodies present in their chloroplasts.

Bangiophyceae have simple thalli of a filamentous or parenchyma-like structure where meristematic activity is sometimes intercalary, sometimes by apical cell or sometimes diffuse. Little is known about their life-cycles, but in a few *Porphyra* species there appears to be alternation of heteromorphic generations. Sporangia are poorly differentiated on the whole and the behaviour of spores after release is not clear. It is possible that the Bangiophyceae contains a heterogeneous collection of unrelated plants that must be further split up.

Kylin's five Orders of his Subclass Bangioideae (= Class Bangiophyceae) are separated chiefly on the basis of vegetative features: the Porphyridiales are unicellular or colonial; the Goniotrichales are filamentous, as are also the Compsopogonales and Rhodochaetales; finally, the Bangiales include filamentous, disc-shaped and leaf-like forms. Only the Rhodochaetales extend their uniseriate filaments by an apical meristem. All other uniseriate filamentous types of Bangiophyceae have intercalary growth. Filaments of Compsopogonales are thalloid and have a habit similar to some simply constructed members of the Family Rhodomelaceae (Ceramiales, Florideophyceae) in that they are polysiphonous. Known only from fresh-water habitats, Compsopogonales have intercalary growth whereas Rhodomelaceae are mostly marine and have apical growth, primarily; their respective reproduction characteristics are very different.

The fifth Order, Bangiales, includes the well-known Genus *Porphyra,* which is the basis of a multi-million Rand aquacultural industry in Japan. Bangiales differ from other Orders of Bangiophyceae by reproducing through spermatia and carpogonia (cf. Florideophyceae). Unlike the Florideophyceae, though, Bangiales do not develop a structure comparable with the carpogonial branch.

The second Class of Rhodophyta, Florideo-

phyceae, contains plants in which sporangia show remarkable conformity. As a result, these plants are regarded as forming a homogeneous group. So far as their life-cycles are concerned, only the Nemaliales appear to be unique. All compound structures are pseudoparenchymatous.

The bases for subdividing this Class into five Orders are discussed in detail in the section which deals with life-cycles and reproduction. All that need be said is that the Gelidiales, recognized as a separate Order by Kylin, are here included in the Nemaliales; this follows the practice recommended by Dixon (1973).

Status of algal taxonomy – Whatever statements about algal relationships have been made above, none can at this stage of our knowledge be held too fixedly (see e.g. Scagel 1966 and Klein and Cronquist 1967). The electron microscope is daily adding new information. Chemical and physiological aspects, too, are receiving more attention than in the past, and with the new techniques available facts are emerging which in time may markedly alter opinions about interrelationships.

Scheme

The following classification scheme is based largely on the works of Fritsch (1935 and 1945) for Chlorophyta and Phaeophyta, and Kylin (1956) for Rhodophyta, mainly because their respective texts give the most comprehensive accounts of currently recognized Genera and are probably possessed by most university libraries.

All generic names appear in italics. Bracketed generic names are either illegitimately used (that is, not in accordance with the Rules of the *International Code of Botanical Nomenclature* of 1972) or are misapplied by Fritsch or Kylin and have substitutes, as listed.

Genera not included in the standard reference-texts (Fritsch and Kylin, respectively) are followed, in parenthesis, by author's name and date of publication.

Certain Genera marked by an asterisk are based on South African species.

Only Genera thought to have southern African representatives appear.

KINGDOM : PLANTES

DIVISION: CHLOROPHYTA
(not recognized by Fritsch 1935)

CLASS: CHLOROPHYCEAE

ORDER: ULOTRICHALES

Family: Ulvaceae
Genus: *Percursaria*
Enteromorpha
Letterstedtia
Ulva
Monostroma
Pringsheimiella

ORDER: CLADOPHORALES

Family: Cladophoraceae
Genus: *Urospora*
Rhizoclonium
Chaetomorpha
Cladophora

ORDER: SIPHONALES

Family: Caulerpaceae
Genus: *Bryopsis*
Caulerpa
Chlorodesmis

Family: Dasycladaceae
Genus: *Acetabularia*
Dasycladus
Neomeris

Family: Derbesiaceae
Genus: *Derbesia*

Family: Codiaceae
Genus: *Avrainvillea*
Boodleopsis
Codium
Halimeda
**Pseudocodium*
Udotea

Family: Valoniaceae
Genus: *Anadyomene*
**Willeella* (Börgesen 1930)
Boodlea
Chamaedoris

Dictyosphaeria
Cladophoropsis
Siphonocladus
Struvea
Valonia
Valoniopsis
Microdictyon

DIVISION: PHAEOPHYTA
(not recognized by Fritsch 1945)

CLASS: PHAEOPHYCEAE

ORDER: ECTOCARPALES

Family: Ectocarpaceae
Genus: **Bachelotia*
Ectocarpus
Streblonema
Family: Myrionemataceae
Genus: Ralfsia
Family: Mesogloeaceae
Genus: Myriocladia
Myriogloea
**Levringia* (Kylin 1940)
**Papenfussiella* (Kylin 1940)
Family: Leathesiaceae
Genus: Leathesia
Family: Spermatochnaceae
Genus: Nemacystus
Stilophora
**Chordariopsis* (Kylin 1940)
Family: Splachnidiaceae
Genus: Splachnidium
Family: Punctariaceae
Genus: Omphallophyllum
Punctaria
Family: Asperococcaceae
Genus: Asperococcus
Petalonia
Endarachne
Scytosiphon
Family: Encoeliaceae
Genus: Chnoospora
Colpomenia
Hydroclathrus
Iyengaria

ORDER: SPOROCHNALES

Family: Sporochnaceae
Genus: Carpomitra
Sporochnus

ORDER: DESMARESTIALES

Family: Desmarestiaceae
Genus: Desmarestia

ORDER: LAMINARIALES

Family: Laminariaceae
Genus: Laminaria
Family: Lessoniaceae
Genus: Macrocystis
Family: Alariaceae
Genus: Ecklonia

ORDER: SPHACELARIALES

Family: Sphacelariaceae
Genus: Sphacelaria
Family: Stypocaulaceae
Genus: Halopteris
Phloiocaulon

ORDER: DICTYOTALES

Family: Dictyotaceae
Genus: Dictyota
Dictyopteris
Dilophus
Homoeostrichus
Padina
**Pocockiella* (Papenfuss 1943)
Spatoglossum
Stoechospermum
Stypopodium
Zonaria

ORDER: FUCALES

Family: Fucaceae
Genus: **Axillariella* (not *Carpoglossum* – see Silva 1959)
Seirococcus
Family: Cystoseiraceae
Genus: Bifurcaria
**Bifurcariopsis* (Papenfuss 1940)
Hormophysa

Cystophora
Cystoseira
Family: Sargassaceae
Genus: Carpophyllum
Sargassum
Turbinaria
Family: Hormosiraceae
Genus: Hormosira

DIVISION: RHODOPHYTA
(not recognized by Kylin 1956)

CLASS: BANGIOPHYCEAE
(Subclass: Bangioideae, Kylin 1956)

ORDER: GONIOTRICHALES

Family: Goniotrichaceae
Genus: Goniotrichum

ORDER: BANGIALES

Family: Erythropeltidaceae
Genus: Erythrotrichia
Family: Bangiaceae
Genus: Bangia
Porphyra

CLASS: FLORIDEOPHYCEAE
(Subclass: Florideae, Kylin 1956)

ORDER: NEMALIALES (Nemalionales)

Family: Chantransiaceae
Genus: Acrochaetium
Conchocelis
Family: Helminthocladiaceae
Genus: Liagora
Helminthocladia
Helminthora
Nemalion
Family: Chaetangiaceae
Genus: Scinaia
Pseudogloiophloea (not *Gloiophloea* – see Papenfuss 1968)
Chaetangium
Galaxaura
Family: Bonnemaissoniaceae
Genus: Delisea
Family: Gelidiaceae (Order: Gelidiales)
Genus: Gelidium
**Beckerella*
**Suhria*
**Ptilophora*

ORDER: CRYPTONEMIALES

Family: Rhizophyllidaceae
Genus: Chondrococcus (Desmia)
Ochtodes
Family: Squamariaceae
Genus: Peyssonnelia
Family: Hildenbrandiaceae (Hildenbrandtiaceae)
Genus: Hildenbrandia (Hildenbrandtia) (Chamberlain 1962)
Family: Corallinaceae
Tribe: Lithothamnieae ("Die Lithothamnion Gruppe")
Genus: Lithothamnion
Tribe: Lithophylleae ("Die Lithophyllum Gruppe")
Genus: Metamastophora
Lithophyllum
Dermatolithon
Melobesia
Choreonema
Tribe: Corallineae ("Die Corallina Gruppe")
Genus: Amphiroa
Cheilosporum
Corallina
Jania
**Arthrocardia*
**Duthiophycus (Duthiea)* (Tandy 1938)
Family: Cryptonemiaceae (Grateloupiaceae)
Genus: Grateloupia
Aeodes
**Pachymenia*
**Phyllymenia*
Polyopes
Prionitis
Thamnoclonium
**Codiophyllum*
Family: Kallymeniaceae (Callymeniaceae)
Genus: Pugetia
Callophyllis
Kallymenia (Callymenia)
**Thamnophyllis* (Norris 1964)
Family: Choreocolaceae
Genus: Choreocolax

ORDER: GIGARTINALES

Family: Nemastomaceae
Genus: Nemastoma
Schizymenia
Family: Gracilariaceae
Genus: Gracilaria (includes *Corallopsis*)
Gelidiopsis
Tylotus
Family: Plocamiaceae
Genus: Plocamium
Plocamiocolax
Family: Sphaerococcaceae
*Genus: *Heringia*
Caulacanthus
**Phacelocarpus*
Family: Sarcodiaceae
Genus: Trematocarpus (includes **Dicurella*)
Sarcodia
Family: Solieriaceae
Genus: Anatheca
Solieria
Family: Rhabdoniaceae
Genus: Catenella
Rhabdonia
Erythroclonium
Family: Rhodophyllidaceae
Genus: Calliblepharis
Family: Hypneaceae
Genus: Hypnea
Family: Mychodeaceae
Genus: Mychodea
Ectoclinium
Family: Acrotylaceae
*Genus: *Reinboldia*
Family: Phyllophoraceae
Genus: Gymnogongrus
Family: Gigartinaceae
Genus: Iridaea
Gigartina

ORDER: RHODYMENIALES

Family: Rhodymeniaceae
Tribe: Chrysymenieae ("Die Chrysymenia Gruppe")
*Genus: *Erythrymenia*
Tribe: Botryocladieae ("Die Botryocladia Gruppe")
Genus: Botryocladia
**Myriophylla* (not *Myrioglossa* – see Papenfuss 1958)
Tribe: Rhodymenieae ("Die Rhodymenia Gruppe")
Genus: Rhodymenia
**Epymenia*
Tribe: Hymenocladieae ("Die Hymenocladia Gruppe")
Genus: Hymenocladia
Family: Lomentariaceae
Tribe: Champieae ("Die Champia Gruppe")
*Genus: *Champia*
Chylocladia

ORDER: CERAMIALES

Family: Ceramiaceae
Tribe: Crouanieae ("Die Crouania Gruppe")
Genus: Antithamnionella
Antithamnion
Tribe: Dohrnielleae ("Die Dohrniella Gruppe")
Genus: Callithamniella
Tribe: Ceramieae ("Die Ceramium Gruppe")
Genus: Ceramium
Centroceras
Microcladia
**Carpoblepharis*
**Syringocolax*
Tribe: Spyridieae ("Die Spyridia Gruppe")
Genus: Spyridia
Tribe: Wrangelieae ("Die Wrangelia Gruppe")
Genus: Wrangelia
Tribe: Callithamnieae ("Die Callithamnion Gruppe")
Genus: Callithamnion
**Aristothamnion*
Tribe: Compsothamnieae ("Die Compsothamnion Gruppe")
Genus: Pleonosporium
Tribe: Griffithsieae ("Die Griffithsia Gruppe")
Genus: Griffithsia
Tribe: Spermothamnieae ("Die Spermothamnion Gruppe")
Genus: Spermothamnion
Tribe: Ptiloteae ("Die Ptilota Gruppe")
Genus: Gymnothamnion
Euptilota
Tribe: Dasyphileae ("Die Dasyphila Gruppe")
Genus: Dasyphila
Family: Delesseriaceae
Subfamily: Delesserioideae (Delesserieae)
Tribe: Caloglosseae ("Die Caloglossa Gruppe")
Genus: Caloglossa
Tribe: Hypoglosseae ("Die Hypoglossum Gruppe")
*Genus: *Bartoniella*
**Botryocarpa*
Tribe: Membranoptereae ("Die Membranoptera Gruppe")
*Genus: *Holmesia*

Tribe: Delesserieae ("Die Delesseria Gruppe")
Genus: Apoglossum
Delesseria
Tribe: Sarcomenieae ("Die Sarcomenia Gruppe")
Genus: Taenioma
Platysiphonia
Tribe: Claudeeae ("Die Claudea Gruppe")
Genus: Vanvoorstia
Subfamily: Nitophylloideae (Nitophylleae)
Tribe: Phycodryseae ("Die Phycodrys Gruppe")
Genus: Polyneura
Tribe: Pollexfenieae ("Die Papenfussia Gruppe")
*Genus: *Pollexfenia (Papenfussia)*
Tribe: Myriogrammeeae ("Die Myriogramme Gruppe")
Genus: Myriogramme
Neuroglossum
Tribe: Cryptopleureae ("Die Cryptopleura Gruppe")
Genus: Acrosorium
Hymenena
Botryoglossum
Gonimophyllum
Tribe: Martensieae ("Die Martensia Gruppe")
Genus: Martensia

Association within the Delesseriaceae uncertain:

Genus: Rhizophyllum

Family: Dasyaceae

Genus: Dasya
Dasyopsis
Heterosiphonia

Family: Rhodomelaceae

Tribe: Polysiphonieae ("Die Polysiphonia Gruppe")
Genus: Polysiphonia
Alsidium
**Rhodomelopsis*
**Carradoria*
**Tayloriella*
Digenea
**Digeneopsis* (Simons 1970)
Pachychaeta
Bryocladia
Tribe: Lophothalieae ("Die Lophothalia Gruppe")
Genus: Murrayella
Tribe: Levringielleae ("Die Levringiella Gruppe")
*Genus: *Stromatocarpus*
Colacopsis
**Melanocolax*
Tribe: Pterosiphonieae ("Die Pterosiphonia Gruppe")
*Genus: *Pterosiphonia*
Dictymenia
Tribe: Bostrychieae ("Die Bostrychia Gruppe")
Genus: Bostrychia
Tribe: Placophoreae ("Die Placophora Gruppe")
*Genus: *Placophora*
Tribe: Streblocladieae ("Die Streblocladia Gruppe")
Genus: Streblocladia
Microcolax
Tribe: Herposiphonieae ("Die Herposiphonia Gruppe")
Genus: Herposiphonia
Tribe: Polyzonieae ("Die Polyzonia Gruppe")
Genus: Dasyclonium
**Polyzonia*
Leveillea
Tribe: Lophosiphonieae ("Die Lophosiphonia Gruppe")
Genus: Lophosiphonia
**Falkenbergiella*
Ophidocladus
Tribe: Amansieae ("Die Amansia Gruppe")
Genus: Kuetzingia
Amansia
Vidalia
Neurymenia
Tribe: Chondrieae ("Die Chondria Gruppe")
Genus: Chondria
Acanthophora
Tribe: Laurencieae ("Die Laurencia Gruppe")
Genus: Laurencia
Janczewskia

Family: (unknown)

Genus: Onychocolax (Pocock 1956)

ORDER: (UNKNOWN)

*Genus: *Aiolocolax* (Pocock 1956)
Episporium

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GLOSSARY

abaxial – describing that part of a supported organ that faces away from the supporting organ (cf. adaxial)
accessory pigment – See: *pigment, accessory*
accessory tissue – See: *tissue, accessory*
acellular – lacking segregative material within a bounding layer (cf. cellular)
acrogenous – generating tissue at the extremity
acropetal – produced in a succession towards the apex (cf. basipetal)
acuminate – tapering to a point
adaxial – describing that part of a supported organ that faces the supporting organ (cf. abaxial)
adnate – attached over the entire length
aegragrop(h)ilous – describes a nest-like structure consisting of intertwined filaments
Alga – one of a heterogeneous collection of plants characterized by being autotropic through photosynthesis, by reproduction through partly or entirely unprotected spores, and by a potenial for forming complex thalli. Plural: Algae
Algae – plural of *Alga*
Algae, Blue-Green – See: *Cyanophyta*
Algae, Brown – See: *Phaeophyta*
Algae, Green – See: *Chlorophyta*
Algae, Red – See: *Rhodophyta*
alternate – where successive lateral members of an axis are on opposite surfaces of that axis
alternation of generations – See: *generations, alternation of*
amoeboid – lacking definite shape
amorphous – lacking definite form
anastomosis – the convergence of structural elements (cf. branching). Plural: anastomoses
ancipitous – two-edged; two-headed
anisogamous – relating to anisogamy
anisogamy – syngamy involving gametes of unequal size (cf. isogamy)
annular, annulated – ring-like; marked by a series of rings
annuli – plural of *annulus*
annulus – a ring; a ring-like feature. Plural: annuli
antheridia – plural of *antheridium*
antheridiophore – an axis carrying one or more antheridia or spermatia (cf. spermatangiophore)
antheridium – the reproductive organ of lower plants in which male gametes are produced. Plural: antheridia
antherozoid – a motile gamete
anticlinal – in planes perpendicular to the surface referred to (cf. periclinal)
apex – the distal tip. Plural: apices
apical – appertaining to the apex
apical cell – See: *cell, apical*
apices – plural of *apex*
apiculate – furnished with a flaccid, pointed tip
apogamy – reproduction from a somatic gametophytic cell whose nucleus is in the diploid phase, without the agency of gametes
apomixis – reproduction through gametes that fail to conjugate presumably because such gametes are already diploid
applanate – horizontally expanded so as to be flat or nearly so
apposed – abutting on
appressed – in close physical contact
arachnoid – covered with or composed of long loose hairs to resemble a cobweb
arboriform – tree-like
arcuate – bent like a bow
areolate(d) – punctuated with small cavities or spaces
articulate(d) – jointed
aseptate – lacking septa; uncompartmented (cf. septate)
asexual – neuter
asexual reproduction – See: *reproduction, asexual*
attenuate(d) – narrowed; tapered
autotrophe – an organism synthesizing organic materials from inorganic sources (cf. heterotrophe)
autotrophic – relating to an autotrophe
autotrophy – a condition in which an organism derives its nourishment from inorganic sources
auxiliaries – loose term for auxiliary cells
auxiliary cell – See: *cell, auxiliary*
auxocaulous – describing those species of Sphacelariales (Phaeophyta) whose primary tissues broaden after they are formed (cf. leptocaulous)

axes – plural of *axis*
axil – the angle formed between an axis and its lateral
axile – belonging to the axis
axillary – relating to the axil
axis – a line or point forming the centre of an object; a more or less continuous flat or rounded column bearing laterals. Plural: axes
axis, primary – first-formed axis

basal – referring to the base
base – the proximal tip or surface constituting the bottom of a structure
basipetal – produced in a succession towards the base (cf. acropetal)
basiphyte – the plant forming the substratum for another
behaviour, cycling – a description of a life-cycle
benthic – associated with or related to the ocean bottom
bifarious – arranged in two vertical files along an axis (cf. multifarious, trifarious, unifarious)
bilateral – two-sided; either originating in or turned to two sides (cf. unilateral)
bilateral symmetry – See: *symmetry, bilateral*
bilocular – having two cells or compartments separated by a septum (cf. plurilocular, unilocular)
binomial – a name having two parts
binomial, biological – a two-part Latinized term identifying a biological entity and consisting of, first, a proper noun (generic name), and, second, an epithet in lower case – the epithet may be an adjective or a substantive (if an adjective then it qualifies the generic name, but if a substantive then it takes the genitive case)
biological binomial – See: *binomial, biological*
biological cell – See: *cell, biological*
biological cell-division – See: *cell-division, biological*
biological nucleus – See: *nucleus, biological*
bipinnate – describing a pinnate structure in which the pinnae are themselves pinnate
biseriate – arranged in two rows or columns (cf. multiseriate, uniseriate)
blade – the expanded flattened portion of a leaf or leaf-like structure
Blue-Green Algae – See: *Cyanophyta*
Blue-Greens – See: *Cyanophyta*
body,plant- – See: *plant-body*
branch, carpogonial – a specially differentiated microscopic somatic filament whose terminal cell is the carpogonium
branch, lateral – a subordinate member of an axis: an axis originating subterminally on another axis
branch, lateral, determinate – a lateral member or branch having limited growth potential
branch, lateral, indeterminate – a lateral member or branch having unlimited growth potential
branching, hemiblastic – a type of branching found only in the Sphacelariales (Phaeophyta) and involving only half of a primary cell (cf. branching, holoblastic)
branching holoblastic – a type of branching found only in the Sphacelariales (Phaeophyta) and involving an entire primary cell (cf. branching, hemiblastic)
branching, order of – sequential status of a lateral member relative to the axis, thus, a second-order branch is a branch of the first-formed axis
Brown Algae – See: *Phaeophyta*
Browns – See: *Phaeophyta*
byssoid – composed of fine threads

caespitose – forming a pile as in a carpet
calathiform – almost hemispherically cup-shaped
calcarate – furnished with a spur
calcareous – chalk-like; limy
callus – a pad-like thickening
canaliculate – channelled with a longitudinally running furrow
capitate – expanded apically into a knob
carnose – fleshy or pulpy
carbohydrate – an organic chemical compound containing only the elements carbon, hydrogen and oxygen, usually with the general formula $C_X(H_2O)_Y$
carpogonia – plural of *carpogonium*
carpogonial branch – See: *branch, carpogonial*
carpogonium – the functional non-motile female reproductive organ in the Rhodophyta (cf. oogonium). Plural: carpogonia
carpospore – a spore released by a carposporophyte and occurring only among members of the Florideophyceae (Rhodophyta)
carposporophyte – the parasitic thallus produced directly or indirectly from the zygote in Florideophyceae (Rhodophyta)
cartilaginous – gristly and tough
caulescent – becoming stalked; describing a structure in which a stalk is apparent
cauliform – having the shape of a stalk
caulotaxy – the arrangement of stems on their parent axis
cell – an entity having a definite boundary (cf. plant-cell)
cell, apical – a single meristematic cell differentiated at the apex of an axis
cell, auxiliary – a somatic cell that produces gonimoblast filaments following fertilization of an associated carpogonium

cell, biological – a vital organism or component of such an organism, distinguished by having a semipermeable membrane bounding a protoplast

cell, column- – See: *column-cell*

cell, cortical – a cell of the cortex

cell, diploid – a cell whose nucleus is in the diploid phase

cell, germ- – See: *germ-cell*

cell, haploid – a cell whose nucleus is in the haploid phase

cell, pericentral – one of several cells attached directly to and surrounding a column-cell; typically present in members of Ceramiales (Florideophyceae, Rhodophyta)

cell, plant- – See: *plant-cell*

cell, propagative – a cell produced specifically to procreate an organism; a germ-cell

cell, somatic – a single biological cell of non-reproductive tissue

cell, supporting – the cell that supports a carpogonial branch besides other filaments in members of the Florideophyceae (Rhodophyta)

cell wall – See: *wall, cell*

cellular – describing a structure that is compartmented (cf. acellular)

cellulose – the chemical substance of which most of a plant's wall material is composed; a polymerized form of glucose

cell-division, biological – multiplication of biological cells by processes unique to living tissues (cf. mitosis; meiosis)

cell-division, nucleur – See: *mitosis; meiosis*

cell-division, segregative – a type of cell-division peculiar to some species belonging in the Family Valoniaceae (Siphonales, Chorophyceae, Chlorophyta) in which some nuclei of a coenocyte become segregated from the rest by septa

cell-division, somatic – See: *mitosis*

centrifugal development – See: *development, centrifugal*

centripetal development – See: *development, centripetal*

cerebriform – superficially folded as in a mammalian brain

Chlorophyta – a Division of the Plant Kingdom in which reproduction is through exposed spores not enveloped by vegetative tissue, and photosynthesis is conducted with the agency of pigments exactly like those of flowering-plants

chloroplast – an organelle containing photosynthetic and accessory pigments

chromosome – an organelle carrying factors of inheritance and contained within a biological nucleus

Chrysophyta – a Division of the Plant Kingdom containing microscopic unicellular organisms or macroscopic conglomerates of single cells that have peculiar xanthophylls and carotenes as accessory pigments

cilia – plural of *cilium*

ciliate(d) – bearing cilia

cilium – a submicroscopic or microscopic whip-like organelle emerging from a living cell. Plural: *cilia*

circinnate – completely or partially coiled

clathrate – latticed or pierced with apertures

clavate – club-shaped

coalescent – merging with another but without losing identity

coenocyte – an organism or segment of an organism containing more than one nucleus within a single plasmalemma

coenocytic – appertaining to a coenocyte

collateral – standing alongside

column-cell – a cell forming part of the uniseriate filament fundamental to a uniaxial structure

compressed-cylindrical – describing an axis which is elliptical in transverse section

concentric – relating to circles having the same centre but different radii

conceptacle – a minute sporogenous pit in the surface tissues of some Algae

confervoid – composed of threads

confluent – blended into one

conjugate – to perform syngamy, especially involving gametangia

conjugation – a fusion of two germ-cells involving merging of the nuclear material from both. Often used specifically for a union of gametangia

connate – united either when formed or subsequently

connecting filament – See: *filament, connecting*

connection, pit – a feature peculiar to the Florideophyceae (Rhodophyta) in which adjacent cells have cytoplasmic continuity through incomplete septation

convolute – rolled round or back

coralline – an Alga belonging in the Family Corallinaceae (Cryptonemiales, Florideophyceae, Rhodophyta); coral-red; like, or, composed of, coral

coriaceous – like leather or parchment

corneous – having a horny texture

corniculate – furnished with a small horn

coronate – crowned; having a corona

cortex – the peripheral tissue of a thallus containing (in Algae) photosynthetic pigments and usually characterized by dense compacting of its component elements which may be either cellular or filamentous. Plural: cortices

cortical cell – See: *cell, cortical*
corticate(d) – covered by a cortex (cf. ecorticate, uncorticated)
cortices – plural of cortex
corymb – a flat-topped or convex cluster of digits
corymbose – like a corymb in arrangements of parts
costa – a rib (of raised tissue in Algae). Plural: costae
costae – plural of *costa*
crenate – scalloped or crinkled
crispate – curled or undulating
cristate – crested
cruciate – cruciform; arranged in the form of a cross
cruciate tetrasporangium – See: *tetrasporangium, cruciate*
crustose – hard and brittle
cultrate – knife-sharp; sharp-edged and pointed
cuneiform – having a wedge-shape; triangular in outline
curvilinear – flat, unilaterally arched and with parallel edges
cuticle – a peripheral, acellular, often waxy, skin
Cyanophyta – a Division of the Plant Kingdom in which nuclei are diffuse, reproduction is asexual or vegetative, and accessory pigments include phycoerythrin-*c* and phycocyanin-*c*
cycle, life- – See: *life-cycle*
cycling behaviour – See: *behaviour, cycling*
cyclospory – a type of life-cycle of the Fucales (Phaeophyta) in which the gametophyte, normally present in the life-cycles of Algae, does not occur
cyme – an inflorescence developing centrifugally in a sympodial fashion
cymose – in the manner of a cyme
cystocarp – a cyst-like structure containing gonimoblast filaments
cytokinesis – the separation of daughter cells following nuclear division
cytology – the study of cell-contents
cytoplasm – that part of the protoplasm that excludes the nucleus
cytoplasmic – relating to cytoplasm

decurrent – describing filaments growing apposed to and in a basipetal direction on a parent axis
deltoid – shaped like a triangle
dendroid – having a tree-like form
determinate lateral – See: *branch, lateral, determinate*
diaphragm – a cellular partition across a hollow thallus
diatom – a member of the Class Bacillariophyceae (Chrysophyta)
dichotomous – relating to dichotomy
dichotomously – in a dichotomous manner
dichotomy – a condition in which an axis branches into two lobes of equal status (cf. pseudodichotomy; polychotomy)
dicotyledonous – describing a flowering-plant having two primordial leaves in the embryo (cf. monocotyledonous)
digit – a finger
digitate – possessing digits; broad, flat and multilobed terminally, as is a human hand
dimorphic – relating to dimorphy
dimorphy – a display of two morphologically different generations by a single species
dioecious – bearing male and female reproductive organs in distinct organisms (cf. heterothallic; monoecious)
diplobiontic – relating to diplobionty
diplobionty – a life-cycle characterized by two distinct diploid generations besides on haploid generation following in strict sequence (cf. haplobionty)
diploid – referring to diploidy
diploid cell – See: *cell, diploid*
diploid generation – See: *generation, diploid*
diploid nucleus – See: *nucleus, diploid*
diploid phase – See: *phase, diploid, nucleur*
diploid thallus – See: *thallus, diploid*
diploidy – the state of possessing in one biological nucleus two sets of the chromosomes characteristic of the organism (cf. haploidy, ploidy and polyploidy)
disciform – flat and circular in outline
discoid – circular in outline and having thick, blunt edges
distal – appertaining to the portion of material remote from the origin or attachment (cf. proximal)
distichous – disposed in two vertical ranks on the same axis
distriate – marked with two parallel longitudinal lines
distromatic – two-layered (cf. monostromatic, polystromatic)
divaricate – strongly divergent
division, cell- – See: *cell-division*
division, nuclear – a fission of a biological nucleus into replicates of itself and containing either the same number of chromosomes as the parent or a dividend of that number; the act by which a living organism multiplies its constituent units or reproduces itself (cf. mitosis, meiosis)
division, reduction – See: *meiosis*
division, somatic – See: *mitosis*
doleiform – barrel-shaped
dorsal – appertaining to the dorsum (cf. ventral)

dorsiventral – relating to dorsiventrality
dorsiventrality – a condition typical of a dicotyledonous leaf, where the two surfaces differ
dorsum – the back; the posterior portion; that surface of a prostrate member further from the substratum; the adaxial surface (cf. venter)

echinate – beset with prickles
ecorticate – entirely lacking a cortex (cf. corticated; uncorticated)
electron microscope – See: *microscope, electron*
ellipsoid – relating to a solid having an elliptical longitudinal section and a circular transverse section
endemic – originating in the relevant geographical area (cf. exotic)
endochrome – the pigmented matter within a plant cell
endogenous – produced from within
endophyte – a plant growing within the tissues of a host organism (cf. epiphyte)
epiphyllous – growing on leaves or leaf-like organs
epiphyte – a plant growing on the surface of any living organism (cf. endophyte)
epiphytic – appertaining to being an epiphyte
erect – upright; negatively geotropic
estipitate – lacking a morphologically distinct stalk or stipe (cf. stipitate, substipitate)
eurythermal – referring to toleration of a wide-ranging temperature régime (cf. stenothermal)
eutrophic – describing an environment enriched with nutrients
evanescent – soon disappearing; lasting only a short time
excrescence – a growth protruding above the general surface
excurrent – relating to a narrowed portion out of or beyond the apex (as, for instance, a mucro)
exogenous – produced from the outside (cf. acrogenous; endogenous)
exotic – originating outside the relevant geographical area (cf. endemic)
eyespot – pigmented microscopic cytoplasmic and phototactic organelle contained by some flagellated cells (cf. stigma)

falcate – sickle-shaped
farinose – covered with a white mealiness
fasciate(d) – describing a massive merging of several members into one unit
fasciation – a bundle caused by a mass of originally independent axes becoming merged into one unit
fascile – a small bundle of axes or other organs
fasciculate – gathered into little bundles
fastigiate – possessed of parallel, clustered and erect branches as in the poplar, *Populus fastigiatus*
favella – a dense, disordered cluster of spores covered with a thin gelatinous sheath. Plural: favellae
favellae – plural of *favella*
fertilization – the act of union between two germ-cells whose nucleur materials are additively conjoined within a single membrane
fibrilliferous – bearing fibres
filament – a thread-like structure
filament, connecting – a secondary filament produced to form a passage for nuclear transfer between carpogonium and auxiliary cell of some Florideophyceae (Rhodophyta)
filament, uniseriate – a transversely septate filament
filamentous – formed of filaments or fibres but remaining slender in girth
fixation – the treatment of an organism so as to solidify or coagulate its components in a form resembling the original
fixative – chemical reagent causing fixation
flaccid – lacking rigidity
flagella – plural of *flagellum*
flagellate(d) – provided with flagella
flagellum – a submicroscopic or microscopic whip-like propulsive organelle emerging from a living cell. Plural: *flagella*
flexed, flexuous – describing axes bent alternately to right and left in a zig-zag pattern
floridean starch – See: *starch, floridean*
fluorescence – absorption of electro-magnetic energy at a particular wave-length and its emission at a longer wave-length (cf. iridescence)
flowering-plant – plant producing flowers whose essential feature is a female germ cell completely enclosed within a somatic tissue that prevents direct contact with the male germ-cell
foliaceous – like a leaf
foliose – describing an axis densely clothed with leaves or leaf-like organs
forcipate – like a pair of forceps
foveolate – marked with small pits; minutely pitted
frond – leaf-like portions of a thallus; often used to define the entire erect portion of a foliaceous or foliose thallus
fructiferous – producing or bearing fruit
fructiform – fruit-like
Fungi – plural of *Fungus*
Fungus – one of a heterogeneous collection of heterotrophic organisms, e.g. molds and mushrooms, often included in the Plant

Kingdom because of their structural resemblance to Algae. Plural: *Fungi*

funicular – resembling a cord or thread

funiliform – having the flexibility and strength of a cord

furcate – forked

fusiform – spindle-shaped

gametangia – plural of *gametangium*

gametangium – the organ producing gametes in or on a thallus. Plural: *gametangia*

gamete – a haploid spore participating in syngamy

gametogenesis – the production of gametes

gametophyte – the haploid generation of a plant (cf. sporophyte)

generation – production of material; a life-span; an organism achieving reproductive maturity

generation, diploid – an organism in the diploid phase

generation, haploid – an organism in the haploid phase

generations, alternation of – a life-cycle in which there is obligatory succession of haploid and diploid somatic organisms

genesis – the act of producing or giving birth to

genicula – plural of *geniculum*

genicule – See: *geniculum*

geniculum – the joint between two successive segments, especially of articulated corallines (cf. intergeniculum). Plural: genicula

geonastic – appertaining to geonasty

geonasty – a growth response to the force of gravity

geonasty, negative – growth away from the centre of the earth

geonasty, positive – growth towards the centre of the earth

germling – the primordial plant emerging from a freed disseminating organ

germ-cell – a cell participating exclusively in the reproductive process (cf. somatic cell)

germ-plasm – protoplasm participating in the reproductive process (cf. somatoplasm)

germination – the initiation of growth in the disseminating agents of a plant

glabrous – smooth and shiny

glandulose – provided with glands or secretory cells

glomerate – clustered closely into a ball or sphere

glomerulate – consisting of many close spherical clusters

gonidangia – plural of *gonidangium*

gonidangium – the organ in the gametophyte producing a germ-cell. Plural: gonidangia

gonidia – plural of *gonidium*

gonidium – a spore (sexual) produced in the gonidangium. Plural: gonidia

gonimoblast tissue – See: *tissue, gonimoblast*

Green Algae – See: *Chlorophyta*

growth, trichothallic – tissue increment by intercalary cell divisions in a terminally situated uniseriate filament

habit – gross appearance or form of plant

habitat – natural home of an organism

hair – an investment of threads; a microscopic, acellular or uniseriate, branched or unbranched, pigmented or hyaline, filament/cell/extrusion on the surface of an organism

hair-scar – the mark on the thallus left by an evanescent hair

hairy – invested with hairs

haplobiontic – relating to haplobionty

haplobionty – a life-cycle in which two haploid generations alternate without the interpolation of a diploid generation (cf. diplobionty)

haploid – relating to haploidy

haploid cell – See: *cell, haploid*

haploid generation – See: *generation, haploid*

haploid nucleus – See: *nucleus, haploid*

haploid phase – See: *phase, haploid nuclear*

haploid thallus – See: *thallus, haploid*

haploidy – the state of possessing in one biological nucleus one set of the types of chromosomes characteristic for the organism (cf. diploidy, polyploidy

haplostichous – relating to haplostichy

haplostichy – a condition of the heterotrichous filament in which erect uniseriate filaments and their branches aggregate congenitally to form a pseudoparenchymatous thallus (cf. polystichy)

haptera – plural of *hapteron*

haptere – See: *hapteron*

hapteron – a single limb of a digitate holdfast. Plural: haptera

haustoria – plural of *haustorium*

haustorium – a filament of a parasitic plant penetrating its host for nourishment. Plural: haustoria

hemiblastic branching – See: *branching, hemiblastic*

heterocyst – a dilated, hyaline cell found characteristically in some filamentous Cyanophyta and seeming to serve as centre for the fixing of nitrogen

heterogeneous – not uniform in kind; a mixture of types; consisting of unlike parts (cf. homogeneous)

heteromorphic – relating to heteromorphy

heteromorphy – different forms; a life-cycle in which the relevant diploid and haploid generations are morphologically distinct (cf. isomorphy)
heterothallic – relating to heterothallism
heterothallism – having differing thalli, so that only one sex is carried on a single gametophyte (cf. dioecious; homothallism)
heterotrichous – relating to heterotrichy
heterotrichy – an organization consisting of both prostrate and erect systems of filaments
heterothrophe – an organism deriving its nourishment from organic sources (cf. autotrophe)
heterotrophic – relating to heterotrophy
heterotrophy – a condition in which an organism derives its nourishment from organic sources (cf. autotrophy)
heterozygous – describing a zygote in which the components of paired genetic characters are different from each other, e.g. wrinkled/smooth or red/green or long/short (cf. homozygous)
hirsute – hairy
holdfast – the attachment organ of a seaweed
holoblastic branching – See: *branching, holoblastic*
homogeneous – consisting of like parts; uniform in kind (cf. heterogeneous)
homology – the comparable origin of parts or structures
homothalic – relating to homothallism
homothallism – having similar thalli, so that both sexes are carried on one gametophyte (cf. monoecious; heterothallism)
homozygous – describing a zygote in which the components of paired genetic characters are identical to one another, e.g. smooth/smooth or red/red or long/long (cf. heterozygous)
hormogone – a fragment of a trichome having peculiar motility and ability to regenerate missing portions of the trichome
host – the organism supporting a parasite
hyaline – colourless and translucent
hydrosphere – the aquatic environment
hypha – a slender, often hyaline, microscopic, branched thread typical of Fungi; any slender elongated filament within a compound thallus. Plural: hyphae
hypha, trumpet- – See: *trumpet-hypha*
hyphae – plural of *hypha*
hypothallia – plural of *hypothallium*
hypothallium – a tissue occurring in encrusting corallines and consisting of the more or less horizontal filaments in the ventral portion of the thallus (cf. perithallium). Plural: hypothallia

imbricate – overlapping like the tiles on a roof
immaculate – unspotted (cf. maculate)
incised – having deep and sharp notches
incurved – curved or coiled inwards or adaxially
indeterminate lateral – See: *branch, lateral, indeterminate*
intercalary – referring to the zone between the terminal extremities of an organ or organism
intergenicula – plural of *intergeniculum*
intergeniculum – a segment of an articulated organ or organism (cf. geniculum)
interstice – space between abutting elements of a compound structure
intramatrical – within a matrix
involute – rolled inwards at the edge
iridescence – changing colour with position (cf. fluorescence)
isogamous – relating to isogamy
isogamy – syngamy in which participating gametes have similar size and other attributes (cf. anisogamy)
isomorphic – relating to isomorphy
isomorphy – a condition in which the gametophytes and sporophytes of a species have similar appearances (cf. heteromorphy)

karyogamy – a fusion of nuclei as in fertilization (cf. mitosis, meiosis)

lacinia – a segment resulting from laceration of a leaf-like structure. Plural: laciniae
laciniae – plural of *lacinia*
lamella – a thin plate or scale. Plural: lamellae
lamella, middle – a membrane segregating, into uninucleate portions, a protoplast that has undergone mitosis
lamellae – plural of *lamella*
lamellate (d) – formed of layers
lamina – the blade portion of a leaf. Plural: laminae
laminae – plural of *lamina*
laminate – having a blade-like form
lanceolate – flattened, narrow and tapering towards the base and apex; shaped like a spear-head
lateral – at the side or on the edge; lateral branch
lateral branch – See: *branch, lateral*
lateral branch, determinate – See: *branch, lateral, determinate*
lateral branch, indeterminate – See: *branch, lateral, indeterminate*
lenticular – lens-shaped; biconvex
leptocaulous – those Sphacelariales (Phaeophyta) whose primary somatic tissues remain at the same diameter as their generative apical cell (cf. auxocaulous)
Lichen – one of a group of composite organisms made up of a Fungus and a microscopic Alga

life-cycle – the course of development, through reproduction, from any given state of an organism to the same again
ligneous – woody
ligulate – strap-shaped
limbate – bordered
linear – flat, narrow, many times longer than wide with more or less parallel edges
lineate – marked with lines
lingulate – tongue-shaped
lithophyll – a fossil leaf
lithophyte – a plant growing attached to stone
lobe – any segment of an organ
longitudinal – referring to the length; parallel with the long axis (cf. transverse)
longitudinal section – See: *section, longitudinal*
lubricous – smooth and slippery
lyrate – lyre-shaped; spathulate and oblong with small lobes near the base

macrophyte – a plant visible to the naked eye
macroscopic – visible to the naked eye (cf. microscopic, ultramicroscopic)
maculate – spotted (cf. immaculate)
matrices – plural of *matrix*
matrix – the acellular material separating cells. Plural: matrices
meatus – an intercellular passage
median membrane – See: *lamella, middle*
medulla – the inner colourless tissue of a thallus
meiosis – a nuclear division in which the diploid state is reduced to the haploid state; a nuclear division in which each of the products contains half the number of chromosomes as did the original (cf. reduction division; mitosis)
meiotic – relating to meiosis
membrane, median – See: *lamella, middle*
membrane, semipermeable – a membrane passing the solvent but not the solute of the solution
meristem – a tissue capable of repeated segmentation
meristematic – relating to a meristem
meristoderm – a meristematic zone at or near the periphery of a thallus
microscope – an instrument rendering magnified images of objects placed near its focal planes
microscope, electron – microscope making use of an electron beam and magnetic lenses to provide magnifications over a very wide range (± × 10 to × 1 000 000) and producing images which can either be photographed or focussed on a fluorescent screen
microscope, electron, scanning – electron microscope providing images of surface structures by reflection of electrons
microscope, electron, transmission – electron microscope revealing structural details by passage of electron beam through a specimen
microscope, optical – a microscope employing translucent lenses and visible light to yield images visible to the eye
microscopic – invisible to the naked eye but resolvable by microscope (cf. macroscopic, ultramicroscopic)
middle lamella – See: *lamella, middle*
mitosis – nuclear division in which the products contain the same number of chromosomes as did the original (cf. meiosis; somatic cell-division)
monocotyledonous – describing a flowering-plant having a single primordial leaf in the embryo (cf. dicotyledonous)
monoecious – both sexes carried by the same adult (cf. homothallic; dioecious)
monopodia – plural of *monopodium*
monopodial – relating to a monopodium
monopodium – a structure in which the primary shoot forms the main axis (cf. sympodium). Plural: monopodia
monosiphon – a uniseriate structure (cf. polysiphon)
monosiphonous – relating to a monosiphon
monosporangia – plural of *monosporangium*
monosporangium – an organ producing a monospore (cf. tetrasporangium) Plural: monosporangia
monospore – a non-motile spore produced singly from the parent cell and apparently behaving asexually
monosporous – referring to a monosporangium
monostromatic – composed of a single layer of cells (cf. distromatic, polystromatic)
morphological – relating to morphology
morphology – the study of form; physical modelling
motile – possessing mobility through the action of propulsive mechanisms such as flagella and jet-streams
µm – a unit of measure representing 0,001 mm
mucro – a short, straight point. Plural: mucrones
mucronate – possessing a short, straight point
mucrones – plural of *mucro*
multiaxial – describing a structure where the primary axis consists of an aggregate of apposed primary filaments (cf. haplostichous; uniaxial)
multicellular – describing an organism consisting of many cells (cf. unicellular)
multifarious – arranged in several vertical files along an axis (cf. bifarious, unifarious)
multifid – forking into many lobes
multinucleate – describing an aseptate protoplast containing many nuclei (cf. uninucleate)
multiseriate – in several columns or rows (cf.

biseriate, uniseriate)
muricate – rough with short, hard, tubular excrescences

naked – without cover or appendage
natant – floating or suspended in a liquid
nemathecia – plural of *nemathecium*
nemathecial – relating to a nemathecium
nemathecium – a bulky, mainly sporogenous, accessory tissue produced on the surface of a thallus. Plural: nemathecia
neutral spore – See: *monospore*
niche, ecological – place and status of organism in an ecological system
nidulate – partially encased by material or lying free within a cavity in material; nesting
node – a knot or knob on an axis, often marking the origin of a branch
nodose – knotty or knobby
nomenclatural – relating to nomenclature
nomenclature – the application of names
non-procarpic – relating to the characteristic absence of procarps
non-vascular plant – See: *plant, non-vascular*
nuclear division – See: *division, nuclear*
nuclear ploidy – See: *ploidy, nuclear*
nucleated – provided with a nucleus
nuclei – plural of *nucleus*
nucleus – the essential principle of a matter or organism
nucleus, biological – the organelle containing hereditary material and controlling behavioural characteristics of living biological cells
nucleus, diploid – a biological nucleus containing two sets of a basic complement of chromosomes
nucleus, haploid – a biological nucleus containing one set of a basic complement of chromosomes
nullipores – encrusting corallines

obconical – inverted cone-shaped (broadest distally)
obcordate – inverted heart-shaped (broadest distally)
obovate – having the outline (in one plane) of an inverted egg (broadest distally)
obovoid – inverted egg-shaped (broadest distally)
obvious – apparent to the unaided eye
ooblast – filaments produced from the fertilized ovum (cf. gonimoblast)
oogamous – appertaining to oogamy
oogamy – fertilization involving a motile sperm and a (non-motile) ovum
oogonia – plural of *oogonium*
oogonium – a swollen cell containing one or more ova or eggs. Plural: oogonia
opposite(ly) – referring to locations in the same transverse line but removed by 180° on an axis
optical microscope – See: *microscope, optical*
order of branching – See: *branching, order of*
organ – a portion morphologically distinct from other portions of an organism
organelle – microscopically distinguishable components of an organ or organism
organism – a biological entity with characteristic behavioural features
ostiole – the orifice of a conceptacle or cystocarp
ova – plural of *ovum*
ovate – having the outline (in one plane) of an egg
ovoid – egg-shaped
ovum – a non-motile female gamete. Plural: ova

palmate – shaped like an open hand
paniculate – cone- or pyramid-shaped as a result of the ordered arrangement of laterals around an axis (cf. racemose)
papilla – a soft superficial gland or protuberance. Plural: papillae
papillae – plural of *papilla*
papillate – bearing papillae
papilloid – like a papilla in shape
paraphyses – plural of *paraphysis*
paraphysis – sterile filament associated with reproductive cells and apparently acting as a spacer
parasite – an organism entirely nourished by another living organism (host)
parasitic – relating to a parasite
parasitism – the state of being parasitic
parasporangia – plural of *parasporangium*
parasporangium – a unilocular sporangium whose spores are irregularly disposed and are produced apparently without a reduction division. Plural: parasporangia
paraspore – spore produced in a parasporangium
parenchyma – a multicellular tissue of thin-walled undifferentiated cells resulting from the mitotic divisions of a meristematic tissue (cf. pseudoparenchyma)
parenchymatous – relating to parenchyma
parietal – carried on or belonging to the wall substance
patent – spreading and, therefore, clearly visible
pectinate – like a comb
pedicellate – stalked
pellicle – a thin skin or membrane
pellucid – transparent or translucent
peltate – shield-shaped, i.e. having a stalk attached centrally instead of marginally
penicillate – like a little brush; pencil-shaped

penultimate – last but one
percurrent – extending throughout the entire length
pericarp – the wall of a fruit or capsule of an ovary
pericentral – surrounding the centre
pericentral cell – See: *cell, pericentral*
periclinal – parallel to the surface (cf. anticlinal)
peripheral – appertaining to the surface
periphery – external boundary or surface
perithallia – plural of *perithallium*
perithallium – most of the tissue constituted by the erect filaments in encrusting corallines and extending to the dorsal surface (cf. hypothallium)
Phaeophyta – a Division of plants reproducing by spores emergent from vegetative tissue and possessing fucoxanthin as an accessory pigment
phase, diploid, nuclear – that part of a life-cycle in which the somatic nuclei are diploid
phase, haploid, nuclear – that part of a life-cycle in which the somatic nuclei are haploid
phase, polyploid, nuclear – a part of a life-cycle in which the somatic nuclei are polyploid
phycology – the study of seaweeds
phyllotaxy – the arrangement of leaves along an axis
phylogeny – ancestral history
pigment, accessory – a pigment, such as fucoxanthin, phycoerythrin, phycocyanin and carotenes, additional to the photosynthetic pigment and participating in absorption of light for photosynthesis
pigment, photosynthetic – a pigment which when excited by light radiates energy used directly for making carbohydrates out of carbon dioxide and water; chlorophyll-*a*
piliferous – bearing or tipped with hairs; hair-pointed
pilose – bearded with soft hair
pinna – one of a longtitudinal series of similar determinate laterals. Plural: pinnae
pinnae – plural of *pinna*
pinnate(d) – bearing pinnae (cf. bipinnate, tripinnate)
pinnule – a secondary, or higher order, branch of a compound leaf or frond
pit connection – See: *connection, pit*
pit plug – See: *plug, pit*
planar – with flat surface
plant – an autrophe using light as a source of energy
plant-body – thallus; the entire cellular structure constituting a plant
plant-cell – a vital unit bounded by a membrane within a rigid cell wall
plant, flowering- – See: *flowering-plant*
plant, non-vascular – a plant (lower) lacking a vascular system
plant, vascular – a plant (higher) possessing a vascular system
plasm, germ- – See: *germ-plasm*
plasmalemma – the cytoplasmic membrane adjacent to the cell wall or bounding layer of a living cell of an organism
plasmogamy – the fusion of cytoplasm of adnate or conjugating cells
plexus – a net-work
ploidy, nuclear – the state of a nucleus in respect of its chromosomal complement relative to the relevant haploid number (cf. diploidy, haploidy, polyploidy)
plug, pit – material effecting the closure of a pit connection
plurilocular – many-chambered (cf. bilocular, unilocular)
plurilocular sporangium – See: *sporangium, plurilocular*
polychotomous – relating to polychotomy
polychotomy – a condition in which an axis branches into several lobes of equal status (cf. dichotomy, trichotomy)
polymer – consisting of many parts; a chemical compounded of many simpler chemical species
polymorphic – having many forms
polymorphy – the state of having many forms; a life-cycle containing many morphologically different generations (cf. dimorphy)
polyploid phase – See: *phase, polyploid, nuclear*
polyploid thallus – See: *thallus, polyploid*
polyploidy – a nuclear state in which there are many sets of the basic set of chromosomes (cf. ploidy, nuclear)
polysaccharide – a polymer whose basic units are sugars
polysiphon – a compound column consisting of many adnate tubes (cf. monosiphon)
polysiphonous – referring to a construction characteristic especially of the Rhodomelaceae (Ceramiales, Florideophyceae, Rhodophyta) in which a simple ring of cells is produced, by longitudinal segmentation, around every cell of a primary uniseriate filament
polysiphony – the polysiphonous construction
polysporangia – plural of *polysporangium*
polysporangium – a unilocular sporangium in which the many spores produced, often by reduction division, are arranged in a compact subspherical mass (cf. monosporangium). Plural: polysporangia
polyspore – spore produced by a polysporangium

(cf. monospore; tetraspore)
polystichous – appertaining to polystichy
polystichy – the process by which a uniseriate filament develops into a parenchyma; a parenchyma derived from segmentation of a uniseriate filament (cf. haplostichy)
polystromatic – many-layered (cf. distromatic, monostromatic)
primary axis – See: *axis, primary*
primordia – plural of *primordium*
primordial – first in a sequence of development
primordium – the first state of an organ; the first form taken by an organ or organism. Plural: primordia
procarp – a construction present in some members of the Florideophyceae (Rhodophyta) in which auxiliary cell and carpogonium occur in filaments arising on the same supporting cell
procarpic – relating to the characteristic possession of procarps
proliferous – bearing vegetative progeny as attached shoots
propagative cell – See: *cell, propagative*
protoplast – matter consisting of a number of complex chemicals organized in specific ways and capable of reproducing all or part of itself through the use of its chemical energy
proximal – appertaining to the portion of material in the region of the origin or attachment (cf. distal)
psammophyte – a plant growing attached to sand grains
pseudodichotomy – monopodial or sympodial branching in which the parent axis and a lateral appear to have equal status (cf. dichotomy)
pseudonemathecia – plural of *pseudonemathecium*
pseudonemathecium – a structure with the appearance of a nemathecium but consisting instead of sporangia immersed in a modified cortex. Plural: pseudonemathecia
pseudoparenchyma – tissue having the appearance of parenchyma but whose juxtaposed cells are apposed to one another rather than commonly derived (cf. parenchyma)
pseudoparenchymatous – relating to pseudoparenchyma
pubescent – covered with downy hair
pulvinate – like a cushion or pad
pustulate – as if covered with small pimples
pyrenoid – an organelle associated with starch granules and present in the chloroplasts of nearly all Green Algae and in some species of Red Algae
pyriform – pear-shaped (broadest distally)
quadrate – square or rectangular
quadrifarious – in four vertical files along an axis (cf. bifarious, multifarious, unifarious)

raceme – a flowering axis in which the oldest flowers are at the base and the youngest at the apex and in which the flowers all have stalks of equal length
racemose – producing laterals as in a raceme (cf. paniculate)
raches – plural of *rachis*
rachis – the axis of a frond or compound leaf. Plural: raches
radial – relating to the radius
radial section – See: *section, longitudinal, radial*
radii – plural of *radius*
radius – a line between the centre and circumference of a circle. Plural: radii
ramification – a branching habit
ramuli – plural of *ramulus*
ramulus – a second or higher order branch. Plural: ramuli
receptacle, reproductive – a fertile branch or branchlet found typically in the Fucales (Phaeophyta)
rectilinear – straight, narrow and flat with parallel edges
recurved – curved or coiled backwards, posteriorly, or abaxially
Red Algae – See: *Rhodophyta*
Reds – See: *Rhodophyta*
reduction division – See: *meiosis*
reniform – kidney-shaped
reproduction – the act of increasing the numbers of an item; a copy of an original
reproduction, asexual – reproduction via germcells which do not conjugate
reproduction, sexual – reproduction via germcells which conjugate
reproductive receptacle – *See: receptacle, reproductive*
reproductive tissue – See: *tissue, reproductive*
reticula – plural of *reticulum*
reticulate(d) – net-like
reticulum – a net or net-work. Plural: reticula
revolute – rolled backwards at the edge; coiled abaxially or posteriorly
rhizoid – an emergent thread, often microscopic and sometimes branched, serving as an attachment organ; a decurrent intercellular filament, like a hypha, arising in the proximal part of a thallus
rhizomatous – like a rhizome
rhizome – a thick elongate root-like stem of a flowering-plant
Rhodophyta – a Division of plants reproducing by

spores at least partly exposed beyond vegetative tissue and possessing the accessory pigments phycoerythrin-*r* and phycocyanin-*r*

rib – an elongated ridge of tissue

rimose – a surface broken with chinks or cracks as in old tree-bark

rostrate – tipped by a beak or similar relatively slender extension

rugulose – wrinkled

saccule – a small bag-shaped object

sagittate – shaped like a barbed arrow-head

saxicolous – growing attached to rocks (cf. lithophyte)

scar, hair- – See: *hair-scar*

scheme, systematic – an arrangement (of organisms) into differential associations

SCUBA – self-contained underwater breathing apparatus

scutate – buckler-shaped

seaweed – a non-vascular macrophyte reproducing by spores

section – a slice of or to slice material; a thin slice of material suitable for examination under a microscope

section, longitudinal – a section made in a plane parallel with the longitudinal axis

section, longitudinal, radial – a longitudinal section made through the centre of a cylindrical axis

section, longitudinal, tangential – a longitudinal section that avoids the centre of a cylindrical axis

section, transverse – section of material made at right-angles to its long axis

secund – an arrangement of organs in a single unilateral file along an axis (cf. unifarious)

segment – a portion of a circle; a unit of a jointed column

segmentation – segment-formation

segregative cell-division – See: *cell-division, segregative*

seirosporangia – plural of *seirosporangium*

seirosporangium – a complex of sporangia occurring terminally in a chain and peculiar to a few monosiphonous members of the Ceramiaceae (Ceramiales, Florideophyceae, Rhodophyta). Plural: seirosporangia

SEM – scanning electron microscope. See: *microscope, electron, scanning*

semipermeable membrane – See: *membrane, semipermeable*

septa – plural of *septum*

septate – compartmented by membranes and other bounding material (cf. aseptate)

septation – act of forming septa

septum – a membranous partition separating adjacent cells of an organism. Plural: septa

seriate(d) – arranged in a series, row, column or file

sessile – describing an organ directly attached to its carrier; unstalked

seta – a bristle; a stalk bearing a sporangium as in some Sphacelariales (Phaeophyta). Plural: setae

setaceous – beset with bristles; bristle-like

setae – plural of *seta*

sexual reproduction – See: *reproduction, sexual*

sheath – a cover moulded to the shape of its contents; a moulded matrix in which filaments are embedded

simple – of one piece or series; unadorned; unbranched

sinus – a depression between adjoining lobes; a bay; an axil

siphon – a tube

siphonous – relating to a siphon

somatic – related to the body

somatic cell – See: *cell, somatic*

somatic cell-division – See: *mitosis*

somatic tissue – See: *tissue, somatic*

somatoplasm – protoplasm that does not participate in the reproductive process (cf. germplasm)

sori – plural of *sorus*

sorus – a superficial tissue consisting of sporangia often mixed with sterile cells. Plural: sori

spat(h)ulate – oblong and attenuated proximally so as to resemble a druggist's spatula (cf. lyrate)

speciation – the evolution of new species from an existing one

sperm – a motile male germ-cell

spermatangia – plural of *spermatangium*

spermatangial – relating to a spermatangium

spermatangiophore – an axis bearing spermatangia (cf. antheridiophore)

spermatangium – an organ containing spermatia. Plural: spermatangia

spermatia – plural of *spermatium*

spermatium – a non-motile male germ-cell, typical of Rhodophyta. Plural: spermatia

spermatozoid – a motile male gamete participating in oogamy. (cf. antherozoid)

spinose – spiny; having spines

spongiose – soft; having the texture of a sponge

sporangia – plural of *sporangium*

sporangial – relating to a sporangium

sporangiophore – an axis carrying sporangia

sporangium – an organ in which spores are produced. Plural: sporangia

sporangium, plurilocular – a many-chambered

sporangium in which individual spores are separated from their neighbours by septa
sporangium, unilocular – an aseptate sporangium containing several spores
spore – a uninucleate germ-plasm
spore, neutral – See: *monospore*
sporogenesis – the production of spores
sporogenous – describing a tissue specialized for the production of spores
sporophore – an axis supporting one or more spores
sporophyll – a leaf or leaf-like structure modified to bear sporangia
sporophyte – the diploid generation in a plant's life-cycle (cf. gametophyte)
sporophytic – appertaining to the sporophyte
squarrose – rough or scurfy on the surface
starch – main storage product of higher plants including flowering-plants; main storage product of Green Algae; polysaccharide based on maltose
starch, floridean – main storage product of Red Algae; a chemical related to starch
stenothermal – referring to toleration of a régime of a limited and prescribed temperature range (cf. eurythermal)
sterile tissue – See: *tissue, sterile*
stichidia – plural of *stichidium*
stichidium – a specialized branch packed with tetrasporangia and typical of some Rhodophyta. Plural: stichidia
stigma – a phototactic organelle present in many flagellated spores (cf. eye-spot); receptor for pollen in flowering-plants. Plural: stigmata
stigmata – plural of *stigma*
stigmatic – relating to a stigma
stipe – the stalk of a frond; any stem-like portion of a thallus
stipitate – provided with a stalk or a stipe (cf. estipitate, substipitate)
stria – a minute groove or channel. Plural: striae
striae – plural of *stria*
striate(d) – marked with longitudinal parallel lines, grooves or channels
stroma – a cushion-like tissue often bearing fruiting bodies; a single layer of cells. Plural: stromata
stromata – plural of *stroma*
stromatic – layered
stupose – tow-like and constructed of long silky hairs
subapical – near the apex
submicroscopic – too small to be resolved by an optical microscope
substipitate – suggesting the existence of a stipe (cf. estipitate, stipitate)
substrata – plural of *substratum*
substrate – a medium for nourishing an organism; a nutrient
substratum – the layer or material to which an organism attaches itself. Plural: substrata
subtend – to extend under or be opposite to
subterminal – near the extremity
subulate – awl-shaped
supporting cell – See: *cell, supporting*
surculi – plural of *surculus*
surculus – a runner attaching a plant to the substratum and supporting erect shoots. Plural: surculi
symmetry, bilateral – describing an object in which one half is the mirror image of the other half
sympodia – plural of *sympodium*
sympodial – appertaining to a sympodium
sympodium – a structure in which the main axis consists of a succession of lateral shoots. Plural: sympodia
syngamy – fusion of two germ-cells in an act of fertilization; fusion of male and female gametes to form a zygote
synonymity – the occurrence of more than one binomial for the same biological entity
system, vascular – continuous, elongated, tubular vessels for transport of liquids; the complex of venous and arterial blood conduits of animals; the microscopic water and solution conduits of all higher plants, including flowering-plants
systematic scheme – See: *scheme, systematic*

tangential section – See: *section, longitudinal, tangential*
taxa – plural of *taxon*
taxon – a defined group in a systematic scheme. Plural: taxa
taxonomic – appertaining to a taxon
taxonomy – the study of taxa
TEM – transmission electron microscope. See: *microscope, electron, transmission*
terete – circular in transverse section
terminal – appertaining to the extremity
ternate – arranged in threes
tessellated – formed of little squares; checkered
tetrahedral tetrasporangium – See: *tetrasporangium, tetrahedral*
tetrasporangia – plural of *tetrasporangium*
tetrasporangium – a unilocular sporangium in which four spores are produced by reduction division. Plural: tetrasporangia
tetrasporangium, cruciate – tetrasporangium with spores arranged in two tiers
tetrasporangium, tetrahedral – tetrasporangium with spores arranged in a pyramid

tetrasporangium, zonate – tetrasporangium with spores arranged in a column
tetraspore – a single spore of a group of four in a tetrasporangium
tetrasporophyte – the generation responsible for producing tetrasporangia
thalli – plural of *thallus*
thallic – See: *thalloid*
thalloid – appertaining to a thallus
thallus – a vegetative plant-body that has relatively simple internal differentiation of tissues and especially lacks vascular elements. Plural: thalli
thallus, diploid – a sporophyte
thallus, haploid – a gametophyte
thallus, polyploid – a thallus whose somatic cells contain polyploid nuclei
thyrsoid – like the flowering-head of a daisy
tissue, accessory – tissue developed secondarily for some special need
tissue, gonimoblast – the sporogenous portion of a carposporophyte
tissue, reproductive – a tissue consisting partly or exclusively of germ-cells
tissue, somatic – body tissue; tissue made up of cells containing somatoplasm
tissue, sterile – tissue potentially reproductive but appearing in a non-reproductive state
tofi – plural of *tofus*
tofus – a soft porous stone formed by precipitation in water and often calcareous, Plural: tofi
tomentose – densely pubescent with a mat of woolly short hair
torulose – cylindrical with swollen portions at intervals; somewhat moniliform
transverse – in a plane at right-angles to the long axis (cf. longitudinal)
transverse section – See: *section, transverse*
trichoblast – apical hair present on numerous Rhodomelaceae (Ceramiales, Florideophyceae, Rhodophyta) more particularly to support the carpogonial branch
trichogyne – the excurrent tube of a carpogonium in Florideophyceae (Rhodophyta) and receptor for a spermatium
trichome – the filamentous portion of a Blue-Green Alga
trichothallic growth – See: *growth, trichothallic*
trichotomous – relating to trichotomy
trichotomously – in a trichotomous manner
trichotomy – a condition in which an axis branches into three lobes of equal status (cf. dichotomy, polychotomy)
tricuspid – terminating in three short points
trifarious – arranged in three vertical files along an axis (cf. bifarious, multifarious)
tripinnate – pinnate to the third order (cf. bipinnate, pinnate)
trumpet-hypha – a special type of filament present in the medulla of Laminariales (Phaeophyceae, Phaeophyta) and whose ends are perforated and often dilated
truncate(d) – ending abruptly; cut off subapically
tubercle – a small excrescence
tuberculous – distorted or blemished by dispersed excrescences
tufa – See: *tofus*
turbinate – shaped like a spinning-top

uliginous – growing in swamps; slimy or muddy
ultramicroscopic – too small to be resolvable by an optical microscope but resolvable by an electron microscope (cf. macroscopic, microscopic)
ultrastructure – structure remaining unresolved under the optical microscope
umbilicate – being shaped like a navel; rounded but depressed in the centre (cf. umbonate)
umbonate – bearing a boss or umbo in the centre (cf. umbilicate)
uncinate – hooked or hook-shaped
uncorticated – See: *ecorticate*
undate – describing a surface marked by a succession of hills
undulate – corrugated
ungulate – clawed or hoofed
uniaxial – having a single axis; describing a compound structure, common to many Algae, in which the fundamental element is a single uniseriate filament (cf. multiaxial)
unicellular – consisting of a uninucleate protoplast bounded by a membrane (cf. multicellular)
unifarious – arranged in a single file along an axis (cf. secund)
unilateral – one-sided; either originating in or all turned to one side or segment (cf. bilateral)
unilocular – one-chambered (cf. bilocular, plurilocular)
unilocular sporangium – See: *sporangium, unilocular*
uninerviate – having a single nerve or rib
uninucleate – describing a protoplast provided with a single nucleus as is usual in individual spores of Algae (cf. multinucleate)
uniseriate – in a single longitudinal series; a single file (cf. biseriate, multiseriate)
uniseriate filament – See: *filament, uniseriate*
urceolate – shaped like a pitcher or urn
ustulate – black as if charred
utricle – a membranous sac-shaped or bladder-shaped appendage; a vesiculate expansion in

an aseptate filament of a *Codium* plant and looking like a cortical cell
utriculate(d) – bearing utricles
utriform – bag-shaped
uvarious – like a bunch of grapes in appearance
uvidous – moist or damp
uviform – grape-like

vacuolar – having vacuoles
vacuole – that portion of the cytoplasm filled with watery sap and bounded by a membrane
vacuous – empty; void
vagiform – having no certain shape
varicose – abnormally enlarged in places
variegated – irregular and patchily discoloured; blotchy
variolate – marked as if pitted
vascular plant – See: *plant, vascular*
vascular system – See: *system, vascular*
vegetative – consisting of somatic tissue
velate – veiled
venation – the pattern of veining
venenose – very poisonous
venose – having veins
venter – the belly; the anterior portion; that surface of a prostrate member nearer the substratum; the abaxial surface (cf. dorsum)
ventral – appertaining to the venter
ventricose – inflated asymmetrically
venulose – profusely veined
vermiculate – worm-shaped; thickened and bent in places
vermiform – worm-like
vernicose – shiny as though varnished
verrucose – warty
verruculose – very warty; covered with warts
vertebrate – contracted at intervals and appearing like a spinal column
vertex – the apex of a triangular or pyramidal body. Plural: vertices
vertices – plural of *vertex*
verticil – an arrangement of parts as radii of a circle as in the spokes of a wheel (cf. whorl)
verticillate – arranged like the spokes of a wheel
veruculate – cylindrical and somewhat pointed; furnished with a small spike apically
vesicle – a small bladder
villose – having a covering of long shaggy hairs
vimineous – bearing long and flexible twigs
vinosus – having the colour of red wine
vinous – See: *vinosus*
virescent – turning green
virgate – wand-shaped; twiggy
virgineous – of purest white
viridescent – turning green
viscid – coated with a sticky substance
volute – rolled up
vulviform – appearing as the lips of a mouth

wall, cell – a permeable, rigid sheath around a cell and mainly consisting of cellulose
whorl – a display arranged like the spokes of a wheel (cf. verticil)

xylem – water-conducting vessels of the vascular system of flowering-plants

zonal – relating to zones
zonate – marked concentrically; banded in parallel strips
zonate tetrasporangium – See: *tetrasporangium, zonate*
zonation – arrangement in parallel bands
zooid – a motile spore or gamete
zoosporangia – plural of *zoosporangium*
zoosporangium – a sporangium producing motile spores. Plural: zoosporangia
zoospore – a motile spore; an asexual motile spore
zygote – a uninucleate diploid cell resulting from syngamy

INDEX TO TAXA

This index includes references to both scientific and common names. Common names of seaweeds are, where appropriate, cross-indexed with their scientific equivalents where their page references also appear.

One of the most important functions to be fulfilled here is to relate seaweeds identified in the Key with the Classification Scheme on pages 86 to 90. For this purpose Genus names alone are sufficient and such entries are usually followed by page references in roman type that refer only to the Classification Scheme. Other page references as may occur opposite Genus names are to the explanatory texts, preceding or following the Key, and, when in bold type, to unspecified species identified in the Key itself – thus, e.g., *Trematocarpus* sp. (for a species yet to be named) and *Pleonosporium* spp. (where the description is appropriate to more than one species of *Pleonosporium*).

Numbers in bold type refer always to pages in the Key itself. Generally, these appear opposite binomials but, as explained above, they may occasionally be appended to Genus names standing alone.

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